Digital Entanglement:

A Micro phenomenological Study of Learning with Digital Devices in a New Zealand Secondary School

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Abstract

For decades now, educators and academics have argued for and against the transformative effect that technology could have on education. However, in spite of the rise of emerging technologies and AI in the classroom, educational theory tends to think of them as a support tool rather than a constitutive component. This study addresses the gap in educational practice and knowledge regarding the description of what happens when students and devices come together. Positioned within a posthuman, postdigital sensibility of relationality, it proposes the metaphor of the Tale of Two Schools as a way to understand how competing paradigms clashing in the classroom are preventing a type of education reform that would integrate digital technologies.

The study adopted a qualitative, interpretive approach focused on the first-person perspective of students' experiences of learning with digital devices. The research is based on data collected primarily from interviews of nine key participants, students of Year 12 and 13 at a secondary school in Aotearoa New Zealand. The study is articulated around two methodologies: micro phenomenology (MP) and micro ethnography (ME) and employs an onto-epistemological overarching framework to emphasise the inseparability between ways of knowing, being, and doing.

The findings from the MP inquiry show that students engage in a process of progressive entanglement with their devices to accomplish a task. Two overarching moments seem to govern the dynamic of that process: a solo (unassisted) drafting, followed by an (assisted) crafting. This structure seems to be fractal, present both at the level of the moments that constitute the experience, and again at the singular moment of connecting with the device. Contrasting the increasing distribution of agency from solo drafting to assisted crafting with the notion of optimal grip makes evident students' process of acquisition and application of patterns of body-readiness. The ME findings suggest that Digital Entanglement results in the emergence of an embodied and cognitive resonance in which the digital becomes an overarching structure where the world and the "I" meet. In this digital environment, artefacts have a unique set of properties that define how they come to be and can be manipulated. Namely, digital artifacts are Explorable, Constructible and Nomadic.

This study contributes to the understanding of the relationship between learners and digital technologies. By examining the hallmarks of this entangled experience, it provides a description of how participants and digital devices come and stay together. Methodologically, it introduces a unique diffractive dialogue between MP and ME, describing not only the topography of the encounter between students and devices but also its dynamics. Integrating these findings with existing theories, the study refines the concept of the digital as a structure of perception and action, proposing a characterisation of digital artefacts as explorable, constructible and nomadic. It advances the current understanding of learning with technologies by highlighting the impact on secondary students' sense-making processes and critically discussing the role of digital technologies. Moreover, it proposes the notion of Digital Entanglement as a challenge to traditional practices in secondary education.

Dedication

Naturally, to Dan, for clearing the path ahead of me so I could follow my passion.

To my parents, who always believed in me no matter what. I wish they could see this achievement.

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor used artificial intelligence tools or generative artificial intelligence tools (unless it is clearly stated, and referenced, along with the purpose of use), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Chapter 1. Introduction

1.1. Introduction

This chapter introduces the genesis of this research, positioning the study in the context of the classroom. First, I begin with a description of the scope of the study and its positioning with educational practice regarding educational change. This is followed by an introduction of the two metaphors that are used to represent the beginning and end of the account of students' entanglement with their devices and the impact this has on their learning that is provided in this study: how a Tale of Two Schools becomes a Tale of Two Selves. These sections explore how a series of conflicting paradigms collide in the classroom resulting in the production of a split learner identity. The chapter continues with the presentation of the research questions and a discussion on the significance of the study. Finally, a detailed outline of the thesis is provided.

1.2. Setting the Scene

I define myself as an educator. I have been a teacher for most of my working life, and it is from that perspective that this research emerges. In the early 1990s, during the first years of my teaching education in my native country of Argentina, I had to give a presentation to my fellow teachers-in-training on a History of the Arts topic. I selected the frescoes at the Sistine Chapel. I wanted to show the frescoes as they were intended to be looked at. So, armed with the only technology that Argentina's public universities could afford back then, I pointed a transparency projector towards the ceiling of our classroom. As grand as our university building was (beautifully Neoclassic), it could not compare to the grandiose expanse of the Chapel. So, I filled the room with echoey music. I did not know it then, but I was creating a technology-mediated “phenomenological bubble” as I modified how the world around us felt.

It was during this time, too, that I came across a text by Roger Chartier (1996) about the transformation in the format of texts into digital. He described these digital texts as hypertexts. This revolution, according to him, is bigger than that of the printing press, because it affords the reader a particular form of utopia (in the etymological sense of *without a place*) that better resembles the way we think. Since then, I have been obsessed with the role of technology in the classroom and its potential to change education. A few decades later, however, the promised revolution has – arguably – failed to realise (Ganimian et al., 2020). Nonetheless, the tension caused by the presence of digital technologies in the classroom remains, as reflected by the recent New Zealand Government's nationwide cell phone ban in schools (Ministry of Education, 2023a). This tension is also captured in the body of literature exploring not only ICT in education but also the global education reform movement (Sahlberg, 2023).

Fuller and Stevenson (2019), building on earlier work by Ball and Olmedo (2013), described how studies focused on education reform have created a language of resistance in relation to change in educational systems that feel “cracked” or broken. It is my personal experience of this feeling of something broken in the classroom that marked the inception of this research. Educational reform is a complex issue with many facets. However, this research tells a story a that relates to the transition of socio-cultural configurations between the Industrial School and the school for the Information or Knowledge Society. More precisely, this study looks into (1) how, as the ubiquitous presence of digital technologies continue to extend secondary students seem to be progressively more entangled with their digital devices; and (2) how long-standing educational paradigms seem to be preventing the reform that is so badly needed to modify teaching practice to account for this entanglement.

In contemporary educational discourse, it is possible to identify references that contrast the Industrial School (Bowles & Gintis, 1976) versus that of the Information (Kohyama, 1968; Webster, 2014) or Knowledge (Gilbert, 2005) Society dichotomy. Both the Information and Knowledge society movement were highly influenced by the irruption of ICT in everyday life. Whilst the former was concerned with the explosion of information and information systems; the latter focused on the result of the free circulation of information: knowledge and knowledge creation (Anderson, 2008). This transition from the Industrial School to the Knowledge Society School required a focus on communication, critical thinking, and collaboration. Hence, towards the 2000s, a new movement focused on the development of the specific skills needed to engage in modern knowledge creation started to emerge: the 21st Century Skills (2007) movement.

Although the language proposed by these movements has been instrumental in describing some of the changes shaping contemporary education, it could also, in the absence of ontological and epistemological reflection, take the reader into oversimplified considerations where the emergence of disruptive technologies and the changing landscape of the world of work are seen as the only challenges traditional education is facing. However, as I intend to demonstrate in this thesis, the chasm is far greater. It is, I argue, a battle of paradigms rather than a question of tools. As the “old world” transitions into a “new one”, the competing paradigms that are central to each of these schooling narratives collide in the classrooms. The resulting (and often failed) attempts to allow both paradigms to coexist is stretching the fabric of schooling and its foundational ideas. Moreover, as educators we find it increasingly challenging to define our learners' defining lines due to the interconnected quality of the digitised world that they inhabit. For the first time in history, we are confronted with the question of where the boundaries of our extended and augmented students are, as resources, people, and infrastructure seem to be everywhere and nowhere at the same time.

The reconfiguration of education and learning, therefore, goes beyond questions relating to economic models, the purpose of education, or contrasting inventories of core skills. Rather, it becomes a vastly more profound movement involving the redefinition of some onto-epistemological ideas around which much of the edifice of traditional education articulates: ideas relating to (1) *what* learning, cognition, and knowledge is and how it occurs; (2) *where* we articulate the process of education; and (3) what are the physical boundaries that define the confines of the learner in this new hyper-connected society.

Therefore, this thesis aims to explore the educational landscape at this time of transition from the old to the new. In particular, the present study is concerned with how education is impacted by the convergence of new models of cognition, by the emergence of a posthuman decentered human subject, and by the rise of a postdigital society, in which the presence of the digital has already integrated into people's lives to such an extent that its presence becomes no longer salient. Converging in the classroom, whilst these shifts pave the way for the emergence of a new kind of school, they are also creating a complex transitional landscape that challenges traditional ideas of education and best practice. These challenges, I argue, are so radical and contrasting to our current understanding of education and schooling that a new theory of education is required. A theory that addresses face-on how students and their digital devices are entangled, and that cognition can only be understood in relation to the ways in which students relate to the world and act in it.

For that reason, in an educational discourse that does not lack references to the dichotomy between the Industrial and Knowledge Society School (e.g., Microsoft Innovative Teaching and Learning Research (2011); The OECD Learning Framework 2030 (2019); The UNESCO Reimagining our Futures Together (2021), the World Economic Forum the Future of Learning and Skills (2015, 2017, 2020) and even Aotearoa New Zealand's own Future-Oriented Learning and Teaching), I would like to start by introducing two new terms in relation to this polarity: the **Anaesthetic** and the **Aesthetic** school**.** Doing so allows me to create new dimensional concepts in which to group the paradigms in question without having to apply previous or existing categories or classification systems. For instance, the teleological centeredness of the term “industrial” when discussing the Industrial School oversimplifies and conflates what the real issue is in relation to this educational model. Thus, the term can mislead the reader to believe that its anachronism stems only from its links to a disappearing industrial system rather than from a complex combination of factors (which will be presented in detail in Chapter 2, Literature Review, and outlined later on in this chapter). Therefore, I would like to propose the term **Anaesthetic School** to refer to the school as we know it instead. I use the term anaesthetic not only because of its connection to some specific forms of education primarily concerned with the transmission of knowledge, but also because of the application of cognitive learning theories that privileged mentality over embodiment. Linguistically, I used this term for its links to the word anaesthesia, a substance that causes a loss of feeling or awareness, a practice that put the body to sleep so it can be operated on. Conceptually, the term is linked to notions associated with the cognitive metaphor of the “computer in the head” and contemplative, vicarious learning (Bandura, 1969) that tend to disregard the non-neural body as a medium for cognition. Moreover, the humanist substrate of the Anaesthetic School is permeated by Cartesian thinking, sharing its tendency to dualisms and the separation of mind and body. In this School, a Cartesian approach (dualist, disembodied) is adopted to conceptualise technology as a tool to solve a problem, rather than a constitutive element of our being-in-the-world.

By contrast, I would like to use the term **Aesthetic School** to signal what I consider to be the alternative to current understandings of schooling. Aesthetic, not only because of its vitalism, but also because of its focus on an ecological, embodied, and perceptual experience of learning and a being-in-the-world. This school is defined by a posthuman, postdigital sensibility, rooted in an extended, embodied, embedded, and enacted lived experience that is mirrored in the digital. Most importantly, this posthumanist education recognises that both human and non-human aspects involved in education are agential. This shift in the centrality of the human has its correlation in the postdigital, where the ubiquitous presence of digital technologies is permanently changing our subjectivities by integrating into our lives and directly and indirectly reshaping the global society (OECD, 2024; Stalder, 2018). They become, I argue, a structure of perception and action that redefines the conditions of possibility.

1.3. A Tale of Two Schools

For decades now, educators and academics have been arguing for and against the transformative effect that technology and new pedagogies could have on education (Bayne et al., 2020; Biesta, 2016; Cecutti et al., 2021; Elstad, 2016; Ganimian et al., 2020; Selwyn, 2016a, 2016b; Weller, 2011, 2020). The ground-shaking 2019-2021 COVID-19 pandemic offered schools around Aotearoa New Zealand and the world a perfect opportunity to test these ideas and to reinvent themselves in order to operate in an environment that removed what, arguably, has been for a long time one of the cornerstones of traditional education: simultaneous presence in space and time. Although remote and/or asynchronous learning were not new to school, the sheer scale of it was. In a matter of days, lockdowns forced schools to either work fully remotely or under a hybrid model. Emergency Learning (Aguilera-Hermida, 2020; Hodges et al., 2020; Rahiem, 2020) fast-tracked digital technology to the forefront of educational practice, as teachers and leadership teams struggled to continue delivering instruction. Despite this opportunity, the promised shift failed to materialise. Instead, “schools used video conferencing and learning management systems to recreate schools as they existed before the pandemic” (Reich, 2021, para. 2). It would seem, after all, that the textbook and the lecture are the preferred immanent formats of education, and that educators only used new media to re-mediate the old approaches (Friesen, 2017), keeping existing systems unchanged. Moreover, the rise of AI in the classroom has disrupted educational practice at an unprecedented speed and depth (Alier et al., 2024). This new technology, half way between a platform and a peer (Lodge, 2024) has impacted both teaching & learning and assessment (Bower et al., 2024), disarticulating what I refer to as the “artefactual assessment” -a practice based usually on a single piece of evidence, such as an essay or examination but also bringing into question who is that ‘knowledgeable other’ from which we learn, when the other is a digital platform (Stojanov, 2023).

The school as we know it (the Anaesthetic School) emerged toward the end of what Vial (2019) calls the Mechanical Technological System. It is towards the end of this first technological system that the Fordist school where a large number of people, following the sound of a bell, came at the same time to the same place to learn according to a standardised schedule explicitly stated (Leadbeater et al., 2005, p. 6) emerged. This school’s goal was to educate the learner in the humanist (Knox, 2019) values of exceptionalism and the human capacity to impose its will and transform its environment in a mechanistic fashion. As such, it was influenced by a particular historical form of bringing the world into existence (an idea that I will later on develop when I address the concept of ontophany, see Section 2.4.2).

Technological systems subtly act on our perception, to the point that "our perception of reality is the result of what our mind builds from the technological operators of reality that it has at its disposal at any given time in history" (Vial, 2019, p. 52). In other words, our understanding and experience of the world around us are shaped by the technology available to us at a given time. Our perception is constructed by our minds according to possibilities that the tools and technologies available afford us, shaping how we perceive and understand that world. Understood in this way, technology becomes much more than a tool to transform into a constitutive part of our experience both of the world and its possibilities. It can be argued, therefore, that our historical narrative as a species has always been closely linked to that of the technological systems that we engender and that, also, enact us. That is to say, in our relationship with technologies we construct both technological systems and social practices. The world, and our perception of it, becomes a performative practice where both human and technological entities acquire both attributes and capabilities "through interpenetration" (Orlikowski & Scott, 2008, p. 455), in a relational entangled ontology (Barad, 2003). In other words, the social and the material emerge together, as illustrated by how interface design can shape learning (Bayne et al., 2020) or different kind of platforms can give rise to alternative forms of social and political practices (Stalder, 2018).

Towards the turn of the millennium, perhaps influenced by the proliferation of digital technologies in most areas of people's lives, a new model of society started to emerge. The resulting tension of this shift found its way into the educational discourse. In the United States, the National Commission on Excellence in Education's report *A nation at risk* (1983) found that the quality of education was declining. This was followed by a report on the demands of the workplace and whether or not young people could meet them. It highlighted how five competencies (resources, interpersonal, information, systems, and technology) and three foundational components (basic skills, thinking skills, and personal qualities) interacted in complicated ways during the course of work, concluding that secondary school learners must develop these competencies and foundation skills (United States Government, 1991).

In Aotearoa New Zealand, this list of skills and competencies resonates with the New Zealand Curriculum Key Competencies. These five key competencies (Thinking; Relating to others; Using language, symbols, and texts; Managing self; and Participating and contributing) were introduced in the early 2000s, and describe the necessary capabilities that people must develop in order to live and learn today and in the future (TKI, 2020). However, the idea of transformation –as well as its linkage to systems and technology– can be traced to very early attempts to redefine the classroom. In 1981, the locally produced Poly (New Zealand's first purpose-built education computer) appeared on the market. After a successful trial in schools, the New Zealand Government placed an order for 5,000 of these computers to be distributed amongst different schools. However, this initial decisiveness was rapidly replaced by a "wait and see" strategy (Nisbet, 2023), as the government cancelled the order the year after (Harpham, 2010). Nevertheless, despite its failure, the Poly scheme opened a conversation in relation to the purpose of computers, particularly in relation to pondering if they were in the classroom to teach students about computing or to use computers to teach students (Nisbet, 2023). Despite the lack of a centralised policy, there was an increasing agreement amongst teachers, parents, and students on the need of computers and computing courses in schools, as reflected in some calls for computer studies to become part of the school certificate examination (Park, 1983). Eventually, the Education and Science Select Committee of the New Zealand Parliament recommended the "provi[sion of] the leadership to deliver both digital capability and 21st century learning environments" (New Zealand Parliament, 2012, p. 39). These suggestions were broadly embraced by educators and decision-makers, resulting in a significant increase in the use of computers in the country's educational system (Pacheco & Melhuish, 2019).

This desire for a transformation of the tools and spaces used in education is mirrored in the 21st-century skills movement. In education, this movement put into question the traditional belief that students can be adequately prepared for the demands of the world using traditional educational practices that are largely focused on knowledge transmission. Instead, the movement focused on the development of a set of abilities and talents that are seen to be crucial for success in the twenty-first century, such as key skills and competencies (Voogt & Roblin, 2010). However, as well as promoting an emphasis on student-centredness and collaboration, this movement also advocated for the effective integration of technology in the classroom and for a strong link between the skills taught at school and real-world applications as a way to prepare students to succeed in the modern world (Wagner, 2008).

Alongside these concepts, influential ideas encouraging the engagement of students in hands-on, real-world projects, such as Project-Based Learning (Barrows, 1996), coincided with the emphasis on the importance of active and experiential learning brought in by the development of constructivist learning theory (Dewey, 1938/1986; Piaget, 1952; Vygotsky, 1978), resulting in approaches where learners are no longer being considered as spectators but as active participants who collaborate in the creation of new ideas and knowledge (Luna Scott, 2015). These new influences in education invited a re-thinking of the traditional roles of the learner, the teacher, and the immediate environment, challenging the notion of knowledge transmission with one of collective knowledge creation in an interconnected world. In this active, experiential learning landscape, mobile technologies –rapidly proliferating at the time– start impacting both on the idiosyncrasy of the learners (Knox, 2019) and the way they relate to the world by blurring the boundaries between educational and social environments (Facer, 2012). Thus, mobile technologies emerged in the classroom as tools capable of creating a seamless, engaging integration between school and home life (McQuiggan et al., 2015), offering opportunities to learn outside the education system (Khaddage et al., 2016), potentially creating new opportunities for students and educators to articulate learning environments that better reflect real-life (Van Schoors et al., 2022), bringing learners and communities together to collaborate free from the confines of time and space (Kearney et al., 2012) and co-construct significant knowledge (Chu & Kennedy, 2011).

One can argue, therefore, that these ideas could have been sufficient to truly shift the ground of educational practice. However, although they proved progressive and have impacted classroom practice, its core Cartesian-Humanist philosophy has remained mostly unchallenged (Knox, 2016, 2019). Mobile technologies emerged in a classroom still heavily defined by human-centredness and internalist notions of cognition. Mirroring the traditional Cartesian differentiation of mind and body, current technologies in the classroom perpetuate the prevalent body-mind dualism by separating software from hardware, information from matter (Penny, 2017) and disregarding the linkages between perception and cognition. However, if we believe that the purpose of education in the 21st century is to learn to thrive in a transforming world (Hannon & Peterson, 2017), the role of lived experience (and therefore, embodiment) becomes central to education. Furthermore, in a digitally interconnected world, the lived experience becomes uniquely extended (Clark & Chalmers, 1998) by the digital (Haraway, 2016). This complex, reticular world presents us with increasingly blurred boundaries between the human and the non-human (Herbrechter et al., 2022), as things appeared not only as an interconnected phenomena but mediated by the affordances of those interconnected platforms.

Posthumanist philosophers have, for over a decade now, questioned the centrality of the notion of Anthropos (from the Greek *ἄνθρωπος*- human being or man), erasing categorical distinctions between the human and other species (Braidotti, 2013). Once lived-experience is no longer conceptualised within the parameters set by the traditional humanist exceptionalism, it becomes intrinsically integrated into an ecosystem of interrelations with the social, the natural, and the technological (Braidotti, 2016a; Braidotti, 2016b), facilitating a transformative phase in our interactions with digital technologies and the social structures and institutions they seem to have integrated into (Knox, 2019).

1.3.1. The Anaesthetic School

To understand why I propose to use the concept of Anaesthetic School to replace that of Industrial School, it is important to explore some of the basic ideas driving practice in the context of secondary schooling, as to direct the attention from political or historical considerations (the Industrial School) towards particular paradigms (Anaesthetic School). The previous sections introduced the inception of this study on my personal experience as an educator and the need for a new approach to educational theorisation. Although Chapter 1, Introduction, is not traditionally the place for a comprehensive literature review, it is essential to introduce a preliminary exploration of the Anaesthetic School and its constitutive paradigms. This section aims to define the Anaesthetic School and trace its foundational concepts to provide a clearer picture of the complexity and depth of the clash of paradigms occurring in the classroom. It should be noted that this is an optional section of the Introduction, designed to offer additional context and reference, and can be visited at a later time. If desired, section 1.3.1 can be skipped and consulted at a later stage. Sub-sections 1.3.1.1 to 1.3.1.4 define the Anaesthetic School in relation four key aspects: (1) the Learnification of education; (2) cognition understood as symbolic; (3) technology seen as a tool; and (4) how in the hands of Humanism, the conflation of all three previous elements results in Cartesian conceptualisation of technology as an outwards-acting tool and therefore devoid of cognitive quality.

1.3.1.1. A *Learnified* Conceptualisation of Education.

Cognition, learning, and knowledge are important notions to any discussion about education. Although interconnected, they are distinct concepts that play differential roles in the broader context of human activity. Different philosophical perspectives prioritise and focus on certain aspects to the detriment of others, so offering an all-encompassing definition without a thorough discussion (which is outside the scope of this study) would be misleading. However, in the context of this study the notion of cognition is closely associated with sense-making and refers to the bringing forth of a world of relevance (Thompson, 2017). Learning is understood as the application of cognition to acquire new skills, behaviours, or knowledge (Bandura, 1977).

Finally, knowledge refers to both a body of information and skills accumulated through learning. It encompasses factual, conceptual, procedural, and metacognitive types (Bloom, 1956).

Anchored on these broad definitions, education emerges as particular arrangements and configurations (Biesta, 2009) that materialise and structure the process designed to facilitate learning (Dewey, 1938). Interestingly, contemporary educational discourse seems to predominantly focus on the concept of learning. The term *learnification* (Biesta, 2009) refers to the discourse where the language of learning is prevalent, and it has been instrumental to educational discourse for around two decades (Campbell, 2019). This relevance is the result of the “remarkable rise in interest in the measurement of education, or, in the lingo of the educational measurement culture, the measurement of educational ‘outcomes’ that has taken over education in the past 20 years” (Biesta, 2009, p. 33), particularly in relation to the Programme for International Student Assessment (PISA).

Talking about education should not be the same than talking about learning (Osberg & Biesta, 2020), because “the point of education is never that students simply learn” (p. 91). Education is an open, semiotic system (Biesta, 2010) in which three clearly differentiated dimensions coexist: qualification, socialisation and subjectification (Biesta, 2009). Qualification is concerned with knowledge, skills and dispositions; socialisation focusses on the transmission of norms, values and traditions; and subjectification is the process of becoming an independent, unique subject. However, when we talk about school, still, the triad learning/assessment/certification tend to be the first to come to mind. Moreover, as a result of the constraints on international examinations, achievement seems to be focused on a selective number of academic domains (Biesta, 2015a). This view is endorsed by Ceder (2020), when he argues that

> In democratic societies (...) teachers uphold the model of the educator [as] administrative staff whose purpose is to help students to reach externally fixed goals. The knowledge goals are firmly connected to international student assessments, among which PISA is the most well-known. Therefore, the concept of the knowledge-centered approach to education is becoming increasingly significant. (p. 15)

This association between learning goals and performance in international student assessments has had a profound impact on educational practice, from policy to local classrooms (Biesta, 2009). As the Organisation for Economic Co-operation and Development (OECD), responsible for PISA, defines student assessment as "a process that helps focus attention towards what matters most in education" (OECD, 2013, p. 140), for most teachers the closest they ever come to considering the purpose of education is to establish what concept they are trying to impart (Bass, 1997). Learning (in its learnified sense) has become central to secondary education practice. The measurement of educational outcomes seems to have become its core purpose, as demonstrated by the recent priorities by the Ministry of Education of New Zealand that focused on lifting achievement (Stanford, 2024). Influenced by its industrial tendency to standardise (Landri, 2016), the Anaesthetic School, has thus established particular configurations and arrangements in response to particular historical paradigms –especially in relation to cognition and knowledge – that perpetuate these particular forms of practice. That is to say, the cognitive brainbound paradigm heritage of the cognitive science combined with the focus on measurement of educational outcomes seem to have produced a learnified system dominated by a narrow, computational understanding of the mind: the metaphor of the computer in the head.

1.3.1.2. A Symbolic Understanding of Cognition.

The origins of the cognitive paradigm can be traced back to Cybernetics, a diverse of multidisciplinary movement that aspired to unify approaches across sciences via a consolidated system's theory (Penny, 2017). In cognitive science, they had decided to take in their own hands the project of describing cognition, a project that up to then had been mostly taken by Psychology (Varela et al., 1991/2017). Although this interest on a wider theory of how systems work met with the initial ideas from behaviourist scientists (e. g.: Guthrie, 1938; Pavlov, 1927; Skinner, 1938; Thorndike, 1914) who working their way from animal behaviour into a more human understanding of cognition, had increasingly included the environment as an important variable. Skinner, for example, understood learning as a reassortment of responses in a complex environmental situation (Schunk, 2008). His reference to the centrality of the environment in his theory is often represented by the statement that "men act upon the world, and change it, and are changed in turn by the consequences of their action" (Skinner, 1957, p. 1). However, "just as 1943 was clearly the year in which the cybernetics phase was born, 1956 was clearly the year that gave birth to cognitivism" (Varela et al., p. 40). By then, the ideas of Chomsky (1956), and McCarthy and Minsky (1955/2006) about computation of symbolic representations were starting to become the dominant voice in cognitive science.

Bandura's early work (1969) proposed that human learning occurs in a social environment and described the relationship between behaviours, environment, and personal factors as a triadic reciprocity. However, later on, he also observed that people could learn to perform tasks by observing only. By differentiating between vicarious (by observation) and enactive (by doing) learning, Bandura, (1977), arguably, inscribe learning within human activity but not necessarily immersed in action. In spite of this, Thagard (2021) argues that it was not until Chomsky's (1959) review of verbal behaviour (Skinner, 1957) that a more human theory of cognition started to appear. Chomsky was very critical of the inadequacies of Behaviourists explanations and proposed his own theory of generative grammar, based on the idea of a recursive, transformational rule system (Wasow, 2003) generating the deep structure underlaying meaning (core semantic relations). Moreover, these ideas highlighting language as the basic mechanism to make sense were supported by Paivio's (1971) research on propositional networks. He proposed knowledge is stored in verbal and visual forms. Whilst concrete objects are stored visually; abstract objects and linguistic structures are stored verbally. These ideas complete a turn into abstract, symbolic representations of knowledge

Moreover, Schema Theory (Anderson & Pearson, 1984) –competing with Pavio's Dual Coding theory– started arguing that knowledge might be represented schematically (Sadoski et al., 1991), adopting the proposition as the basic unit of knowledge comprising all schemata (Anderson & Pearson, 1984), therefore contributing to this idea to became one of the constitutive elements of Information Processing Theory (Taylor & Crocker, 1981). Coincidentally, these findings, together with the advances in computer sciences of the 1960s and 70s, led to the development of the computational theory of the mind (CTM - Fodor, 1975) as the central hypothesis of Cognitive Science (Thagard, 2005). According to CTM, the mind is understood in terms of mental representation of an external reality and the computational procedures operating on those representations.

This primacy of languages, mental representations and schema was also echoed in the field of developmental psychology (another discipline instrumental when it comes to educational design). Piaget and Vygotsky have been identified as the dominant paradigm in Aotearoa New Zealand teacher education (Bennett, 2019; Starkey, 2011). Piaget's (1953) proposed that children create mental frameworks as they interact with their environment (both social and physical), assimilating and accommodating things (in)to it as they interpret their experience. Whilst Vygotsky's points towards mediation (which will be explored in the next section) as the key mechanism in development and learning complete the paradigm of cognition underlying the Anaesthetic school. However, critical voices regarding the Science of Learning (Cognition Education, 2024) are emerging, as made evident by the current debate in relation to the

Science(s) of Learning (Claxton, 2024) questioning the oversimplification of learning and teaching practice.

1.3.1.3. A Utilitarian Conceptualisation of Technology.

In the Anaesthetic classroom configuration, technology emerges captive in a web of philosophical assumptions that constrain its unfolding and the way in which it relates to learners and learning. Beyond the mentalist understanding of learning (Eysenck & Keane, 2015; James, 1890), challenges that preclude technology from being considered as a constitutive element of learning rather than a tool emerge from two distinct yet connected theoretical considerations: (1) Vygotsky's differentiation between tools and signs; and (2) its connection with a Cartesian understanding of an internal versus an external world. The next two sections explore these ideas.

Vygotsky's contributions integrated into a rich tradition of cognitive studies; and while he has made many contributions to the field of psychology, his main impact on contemporary education practice is represented by two main ideas: the zone of proximal development and mediation. For the purpose of this study, I will focus only on his second contribution. Mediation comes from Vygotsky's (1978) distinction between lower and higher cognitive functions. Whilst lower psychological functions are determined by a stimuli-response relationship (e. g. hear a noise-turn to see); higher psychological functions (memory, writing) require the presence of a mediated stimulus (in the form of a tool or a sign) to organise the activity. Human activities are tool mediated semiotics (Lee, 1985). That is to say, in order to control its behaviour, a person uses artificially created stimuli. Human behaviour is influenced not just by the existing stimuli, but also by a new or altered psychological situation that the person creates (Vygotsky, 1978). Tools, artefacts, symbol systems, and specialised discourse are some forms of how social and cultural resources are used for thinking, Mediation is, therefore, a representational model, since it implies acting within the social and physical world in and indirect way, mediated by signs (Wertsch, 2007).

Vygotsky (1978) expanded the notion of tool introduced by Engels (1883/1960) —for whom it represented the transforming action of man in nature to make it serve his ends— and extend it to human environments, as representational tools that transform external activities into internal mediators of cognitive process (Karpov, 2003). Influenced by the historical-materialist Marxist theory of society (Cole & Gajdamaschko, 2007), Vygotsky considered tools and sign systems as social creations that, once internalised, bring about behavioural transformations (Cole &

Wertsch, 1996). Although they are different (tools are externally oriented; whilst signs are internal), they share a mediated function (Bennett, 2019).

An essential aspect of the notion of mediation is that "signs and tools cannot be equated or conflated: this loses the essence of each form of activity and ignores the differences in their historic role and nature, and results in a form of determinism" (Vygotsky, 1978, p. 53). That is to say, tools are externally oriented. They exert an influence on the object of activity, bringing changes in the world (Bennett, 2019), whilst signs are primarily systems socially created and internally oriented that internalise socially rooted activities (Vygotsky, 1978). An implication of this assertion is that understanding digital technologies as a tool, reduces them to an instrument to operate in the world, with an external and instrumental function. In contrast, seeing digital technology as a sign or a system of signs transforms it into a constitutive structure "which partly constitutes the things to which it is applied" (Van den Hoven, 2007, p. 68), and acts as a medium that both impacts on the way we explore reality and mediates its understanding (L. Cardinali et al., 2009; Carr, 2008; Doidge, 2007; Kurzweil, 2005; White, 2013).

The challenge, from the perspective of socio-materiality, is material means are constitutive (Orlikowski & Scott, 2008), Conversely, Vygotsky's mediation sees language as the most powerful process of mental representation by which children transform their experiences and re-organise their mental structures (Jones, 2009). For Barad (2003), the problem with representationalism is that "separates the world into the ontologically disjoint domains of words and things" (p. 811). Vygotsky's mediation, therefore, relies on our subscription to a dualism in the acceptance of both a mental internal and a material external world as "a Cartesian habit of mind" (Barad, 2003, p. 807).

1.3.1.4. Cartesian Understanding of Digital Technology.

Although Descartes has lost his salience amongst intellectuals and philosophers (Hacking, 2013), his ideas are considered foundational of Western modern philosophy. Nonetheless, his arguments in favour of the dualistic distinction of mind and body have been heavily criticised; (Anderson, 2003; Barad, 2003; Bolter, 2016; Braidotti & Asberg, 2018; Braidotti et al., 2016; Chiew, 2012; Faulkner & Runde, 2013; Hacking, 2013; Herbrechter, 2018a, 2018b; Leonardi, 2012; Pischetola & Dirckinck-Holmfeld, 2020; Shapiro & Stolz, 2019; Varela et al., 1991/2017). The next chapter analyses the topic of Cartesian dualism in more detail. However, in this section, I will focus on the implications of a Cartesian-dualistic understanding of digital technology, leaving the philosophical considerations for Chapter 2.

An immediate result of Descartes fundamental Cartesian separation between *res cogitans* (thinking thing or thinking substance) and res extensa (extended thing or extended substance) is that by constructing an ontology of internal versus external, it lays the foundations for the understanding of the world based on a distinction between subjects and objects. Moreover, subjects and objects have distinctive sets of properties, potentialities, and hierarchies that, then, permeates our understanding of digital technology in educational contexts. Maybe supported by Vygotsky's differentiation between tools and signs, the socio-constructivist approaches that have dominated education during the last thirty years "adopt the point of view of an instrumental relationship with technology and show a root in the Cartesian objectivism and dualism" (Pischetola-Dirckinck, 2020, p. 2). That is to say, this Cartesian locatedness that separates the abstract from the concrete transcends into social practices as a hierarchy differentiating knowledge over skills (Penny, 2017, 2020), a differentiation that Stiegler (1998) refers to using the Greek terms of *tekhne* and *epistêmê* (as the separation of practical versus theoretical knowledge).

In the computer sciences is possible to identify two camps. On one side, the digital dualists supporting the idea that the digital world is virtual whilst the physical world is real (Jurgenson, 2011); and on the other those who argue that reality-virtuality can be seen as a continuum (Milgram & Kishino, 1994), there is still a hidden ontological complexity that persists in this differentiation: both support a dualistic distinction by categorising some things as real and some as virtual. Moreover, this dualism is further perpetuated on the separation of information from devices (in the way we refer to a hardware-software distinction). Following Hacking's metaphor, we tend to think of technologies along the lines of analogue bodies and digital minds (Hacking, 2005, pp. 163-164).

In turn, as this dissociation between materiality and mentality permeates computer design, it poses new entrapments. GUI (Graphical User Interface), the most extended form of interaction with digital platforms in the context of the classroom– offers the students a very limited form of embodied interaction. Learners' interaction with their devices are often limited to clicks and scrolls, a phenomenon that Ingold (2024) referred to as a switch from haptic to optic touch that detaches the hand from the body. (Dis)embodiment, then, nests inside a Cartesian differentiation between knowledge and practice, reducing technologies to mere tools to acquire knowledge. However, pre-computational artefacts mapped over the body (like a violin, or an axe) are also seen as instrumental but their salience is that through complex physical engagement with them, they facilitate the emergence of refine skill development (dexterity), essential to our uniqueness as human beings (Penny, 2020). Following this argument, an instrumental part of human learning resides in the inhabitation of our environments, on the body being-in-the-world.

For Ceder (2020), despite the ubiquitousness of materiality, a relationship is seen as a space for interaction between two individuals, and in an educational context, it refers to the interaction between a student and a teacher. Moreover, these interactions are often rooted on a humanistic ontology of exceptionalism, making relations between and amongst things all but invisible.

Going back to the original differentiation between the paradigms of the Industrial and the Anaesthetic school, and to the core concerns of the present study, the obstacles to educational reform do not reside on the links between the current structure of schooling and a particular technological system. It is rooted on a series of interlocking paradigmatic layers: Digital technologies emerge in a classroom imbued with strong linkages to education's foundational Humanist ideas, which consider (digital) technologies not as a structure of perception and action but as an outwards-acting tool that is (more often than not) instrumentalised. Finally, these assumptions are mirrored in a Cartesian-dualistic understanding that fosters a further dissociation between materiality and mentality. This distinction, which will be explored in detail, particularly in Chapter 5, has tremendous consequences for the way students construct their identities.

1.4. Research Questions

By placing performativity as a central topic, this thesis positions itself within "the move toward performative alternatives to representationalism [that] shifts the focus from questions of correspondence between descriptions and reality (e.g., do they mirror nature or culture?) to matters of practices/doings/actions" (Barad, 2003, p. 802). That is to say, the focus of this study is to offer a description of the entangled phenomena in which students and devices come (and emerge) together.

The question of entanglement is presented in more detail in the next chapter. However, for the purpose of this introduction, when I allude to digital entanglement in this study, I am referring to the material, social, human and non-human web of opportunities, constraints, and entrapments emergent from the encounter of participants on phenomena. Highly influenced by an ANT (Actor-Network Theory) sensibility, I use the idea of entanglement as a mechanism to enquire into how human and non-human entities interact to form networks of relationships (phenomena) in which all actors shape the overall outcome.

In the context of this study, entanglement is a metaphor and not a quantum theorisation. In this research being entangled does not just refer to being intertwined but, rather, to emerging together in a configuration where there are no internal and external resources, but an entangled emergence of mutually saturated agencies that cannot be exercised independently (Barad, 2007).

This research aims to develop a comprehensive understanding of how secondary school students become entangled with their digital devices and to explore the implications of this entanglement for learning in contemporary educational contexts. By moving beyond instrumental conceptualisations of technology as mere tools, this study seeks to illuminate the complex, relational, and performative nature of student-device interactions within the transitional educational landscape between the Anaesthetic and Aesthetic Schools. The research endeavours to provide a detailed description of how learners and devices come (and stay) together in entangled configurations, revealing the structure, dynamics and hallmarks of these encounters whilst critically analysing their impact on learning processes, student identity formation, and pedagogical practice.

Through this exploration, the study aims to contribute to educational theory by proposing new conceptual frameworks that can account for the posthuman, postdigital dimensions of learning, challenging the foundational assumptions of the Anaesthetic School and its Cartesian-humanist models. The research seeks to bridge theory and practice by offering educators and policymakers insights that recognise the constitutive role of digital technologies in contemporary learning environments, whilst developing methodological approaches that honour student voices and advance understanding of how posthuman perspectives can reshape educational discourse in a post-digital society.

As I set out on this research journey, I identified two questions to guide the way:

> *What is the nature of the entanglement between secondary school learners and their digital devices?*
>
> *What are the implications of this entanglement for learning in secondary schools?*

I believe that I have answered both of them: a detailed description of the unfolding of the experience of students using digital devices can be found in Chapter 7 and a discussion on the implications of this encounter from the double perspective of the learners' identity is presented in Chapter 5. Chapter 8 examines what the concept of digital entanglement entails in the classroom and explores its implications.

1.5. Significance

This study applies a novel approach to a rapidly evolving and increasingly relevant phenomenon and makes valuable contributions to both education theory and practice as well as philosophy. First, to the best of my knowledge, this study provides a unique inquiry into the black-boxed[1] assemblage of learners and digital devices as it describes not only the structure or hallmarks of that experience but also examines how this entangled experience offers the participants a narrative that scaffolds the deployment of their stories. Also, from a methodological point of view, using Barad's (2007) Diffractive methodology as a theoretical lens to read the finding from each methodological approach through each other, this study engages in a unique dialogue between micro phenomenology (MP) and micro ethnography (ME) to describe the digital phenomenon. While MP enquires into students' understanding of their experience and the interference of assumed narratives, ME provides a tool to examine the process by which some of those narratives are redefined and anchored onto the experience.

Moreover, this research contributes to the current understanding of learning with technologies by exploring how digital technologies impact the way secondary students make sense of their learning environments. It describes the different stages and dynamic of this entanglement and discusses its implications for current pedagogical practice in Aotearoa New Zealand. By assuming a postdigital, posthuman perspective, this study decenters the human position and engages in a critical discussion on the role of digital technologies in education from a relational (rather than hierarchical) perspective. The findings of this research, therefore, provide a significant contribution to inform teaching practice, challenging long-standing industrial and instrumental approaches, and proposing a theory of Digital Entanglement in which the entanglement with the digital defines not only the human experience (as a structure of perception and action) but also challenges current practice and policy in secondary school.

Furthermore, this research makes a contribution to the bodies of literature exploring aspects of embodied cognition in the secondary school context and the widely unexplored domain of

[1] The use of the term black-boxed is inspired by work related to Actor-Network Theory in relation to how complex networks of relationships become simplified and taken for granted.

enactivist approaches to deep (or significant) learning in secondary schools in Aotearoa New Zealand. Finally, by integrating the findings of this research with existing theories, this study proposes a refined understanding of the digital as a structure of perception and action. It argues that digital artefacts are defined by three main properties: explorable; constructible and nomadic; and that as students inhabit this digital ecosystem, they develop a form of cascading adaptations in the form of entangled body readiness.

1.6. Structure of the Thesis

This thesis is organised into 9 Chapters. Chapter 1 introduces the study and describes the theoretical foundation and context, focusing on the classroom as the point of articulation for the clash of a number of paradigms. It contrasts two models of school the Anaesthetic (Industrial) School, which emphasise standardised knowledge transmission, with Aesthetic (Information or Knowledge Society) School, that prioritise critical thinking and experiential learning. The chapter articulates four main characteristics as the tenets of the Anaesthetic School: (1) the Learnification of education; (2) cognition understood as symbolic; (3) technology seen as a tool; and (4) how in the hands the Humanistic tradition and the conflation of three previous elements results in Cartesian conceptualisation of technology as tool and devoid of cognitive quality. The research is guided by questions about the entanglement between secondary school learners and digital devices and the implications this has for learning. The chapter underscores the significance of these questions and outlines the structure of the thesis, calling for a new theory of education that integrates technologies and socio-cultural changes.

Chapter 2 presents a narrative literature review organised into four sections dealing with the four central threads of this research: philosophy; technology; cognition; and material entanglement. Finally, the methodological perspective explores the links between those threads and the selected methodologies. After acknowledging the complexities of composing a literature review on a multidisciplinary topic, the chapter introduces the concept of entanglement to frame the discussion. The chapter references significant studies which explore the use of digital devices in classrooms. However, it argues that these perspectives still treat technology as an external tool, influenced by Cartesian-humanist models, and therefore do not fully address the entanglement between students and digital devices. The chapter foregrounds the idea of digital entanglement, suggesting that students and their cognitive processes are inherently intertwined with their digital devices. This entanglement is framed within historical contexts. The discussion includes philosophical perspectives, particularly the shifts proposed by posthuman and postdigital philosophies, which call for a re-interpretation of educational discourse and challenge traditional ontologies and epistemologies of human centredness. The technological perspective is also explored, emphasising the role of technological systems in shaping perception and social practices. The chapter concludes by discussing the methodological implications of these perspectives, emphasising the need to understand the relational and entangled nature of learning in the context of digital technologies.

The description of the methodology is divided into a theoretical discussion of the epistemological and ontological stances, as well as methodological and data analytical approaches used in this study (Chapter 3); and a practical account of the data collection and analysis process (Chapter 4). More specifically, Chapter 3 describes the methodologies and methods used to collect and analyse the data as well as describing the rationale behind using two complementary methodologies: micro phenomenology as a way to capture the first-person voice in describing the experience; and micro ethnography as a way to describe the socio-material practices. The chapter begins by discussing how narratives surrounding the future and perceptions of technology are often influenced by institutional ideas, leading to a lack of students' voices in educational research. This gap is addressed by proposing a qualitative interpretative research design focused on students' experiences. The research is positioned in an interpretative approach, utilising qualitative-phenomenological and socio-material micro ethnographic methodologies to gather data through tools like observations, semi-structured digital surveys, and micro phenomenological interviews. Data was collected from senior secondary students in a New Zealand school, and the analysis involved micro phenomenological techniques to uncover the structure of experiences. The data collected was analysed using thematic analysis to explore the narratives that scaffold the students' stories. The chapter concludes with ethical considerations, emphasising my own reflexivity and adherence to ethical guidelines.

Chapter 4 describes the intervention, intertwining my personal journey and professional experiences with the methodological adaptations employed. The intervention took place at a high-performing school in New Zealand where I have previously taught. The study focuses on understanding students' learning experiences with digital devices through micro phenomenological interviews and socio-material micro ethnographic analyses. This approach captures both the detailed personal experiences of students and the broader socio-material context of their interactions with technology. The chapter discusses how these methodologies were adapted to secondary school students, ensuring that the focus remains on their authentic experiences. The findings, informed by both micro phenomenology and micro ethnography, are presented in a diffractive dialogue (in which both methodologies are entangled) that honours the students' voices while recognising the influence of macro-narratives on their stories. The chapter concludes by reflecting on the philosophical and methodological contributions of the study, emphasising the dynamic interplay between personal narratives and socio-material engagements in educational research.

The findings are presented in three separate chapters:

Chapter 5 presents the micro ethnographic findings and suggests a new understanding of the digital as a structure of perception. The thematic analysis of the students' interviews identifies two main themes, digital and non-digital interventions, which highlight the tension between traditional and entangled educational practices. The chapter discusses how these themes reveal a duality in students' identities (the Tale of Two Selves) where students resolution of a tension between two narratives defines the direction in which they will perform their identity. It then focuses on tracing the presence of Vial's (2019) dimensions of the digital in the students stories and identifies a series of interactions between these qualities that define the properties of digital artefacts: explorable, constructible and nomadic. The Chapter concludes by identifying Reticularity (interconnectivity) as a phenomenological hallmark of the digital phenomenon.

Chapter 6 also presents micro ethnographic findings. The chapter explores the dynamic interaction between students and digital devices, emphasising how Digital Entanglement creates a new structure of perception and action. The findings present how students, by developing the skills that allow them to effectively navigate the digital environment, develop a cascading form of resonance (Digital Dexterity) that culminates in the digital entanglement of students and devices.

Chapter 7 presents the micro phenomenological findings (the hallmarks of the experience) as well as its intersection with another theoretical framework (Rietveld's Skilled Intentionality). The findings reveal an overarching pattern in students' interactions with digital devices: an initial phase of tentative drafting, followed by a more structured, digitally assisted crafting phase. This pattern reflects a shift from a general, unrefined approach to a focused, optimised effort facilitated by digital tools, organised in 8 circularly integrated phases (Doxa; Contemplating the Task; Drafting; Initial Attempt; Connecting with the Device; Optimising Attempt; Distributed Agency; and Annexation). The chapter also discusses the integration of micro phenomenological (MP) and micro ethnographic (ME) analyses, using diffractive reading to explore the interplay between MP and ME findings. The findings align with Rietveld's Skilled Intentionality Framework, which describes how individuals’ skilful interaction with their environment involves optimised engagement with it, offering a novel understanding of deep learning as body-readiness. The chapter concludes by emphasising the importance of understanding the procedural and embodied dimensions of learning with technology.

Chapter 8 discusses the theoretical foundations and implications of Digital Entanglement. It argues that it represents a shift in *locus* (the place where it happens) rather than *modus* (the general rules by which it happens) in relation to general perceptions of being-in-the-world and forms of material engagement. The chapter introduces a theory of Digital Entanglement. The discussion presented mirrors the four threads introduced in Chapter 2: Philosophy, Technology, Cognition, and Material Engagement, exploring how Digital Entanglement redefines these areas. The theory of Digital Entanglement is rooted in onto-epistemology, Extended Mind Theory and Monism. The chapter further examines the concept of deep learning, proposing that Digital Dexterity and a digitally conditioned society create new cognitive niches for learners which require particular operational dynamics. Finally, it discusses how enculturation with digital tools transforms cognitive systems, highlighting the role of digital artefacts in shaping perception and action. The chapter concludes that Digital Ontophany leads to progressive entanglements, positioning the digital as the place where the body and the world meet and thereby reshaping educational theory to accommodate these changes

Finally, Chapter 9 presents the conclusions and discusses the implications, contributions and the limitations of the study, before suggesting some possible avenues of research and final recommendations.

1.7. Summary

In this chapter I have presented the background of the study and described the personal positionality of the researcher. I have also presented the initial metaphor that captures the problem addressed by this thesis in the form of the Tale of two Schools as a coalition of paradigms in the classroom space. Similarly, after a brief overview of the field of educational reform, I have presented the idea of the Anaesthetic and Aesthetic school as a way to organise these paradigms in a manner that does not contradict pre-existing theoretical models. I have also introduced some of the foundational ideas supporting the notion of the Anaesthetic school as an explanation of the peripheral role of technologies in it.

After presenting the relevance of performativity in the context of this study and a brief introduction to the idea of entanglement, the chapter also introduced the two research questions that guided the present study: (1) What is the nature of the entanglement between secondary school learners and their digital devices?; and (2) What are the implications of this entanglement for learning in secondary schools? This chapter also highlighted the original contributions of this research in terms of unpacking the black box of learners and devices; as well as the study's methodological innovations as the study applied a unique combination of micro ethnography and micro phenomenology to develop a refined understanding offer valuable insight for educators, educational technologists, designers and decision-makers. Finally, this chapter offered a brief summary of each chapter of this thesis.

Chapter 2. Literature Review

2.1. Introduction

The main purpose of this chapter is to present the four central threads of this interdisciplinary study, namely the philosophical, technological, cognitive, and material engagement threads, as well as the methodological framework. First, after acknowledging the research on computers in the classroom carried out by Rana Daoud (2020) and Lauren Bennett (2019) as one of the main influences on the present study, the chapter reflects on the challenge of composing a literature review on a multidisciplinary topic like this. Then I briefly introduce the idea of entanglement, a central argument to this study, to illustrate how the Entanglement of students and device results in a form of co-dependence and shared agencies, potentialities, and limitations. After that, I present some of the constitutive ideas for this research. In the fields of philosophy, the review explores posthumanism and the postdigital as precursors of a new understanding of entangled agencies, whilst also considering one of the main challenges to this shift: Cartesianism. This section examines Spinoza's monism as an alternative to dualism, an approach that is marked by making no fundamental separation between mind and body.

The technology thread explores how technology is an intrinsic aspect to being human and how it possesses a subtle way to influence the social. This section introduces another key concept: ontophany. This term is used to describe how technologies are not just tools but integral parts of our perceptual and existential experiences. The third thread to be introduced is that of the cognitive shift as the central ideas of cognition that define the Anaesthetic School. This thread explores growing salience of embodiment and enaction in the field of education as a way to position educational research in the field of lived experience. The final thread focuses on material engagement. This thread is a theme in itself but also a natural outcome of the previous threads. The material engagement thread explores how agencies and thinking rely on our relationship with physical objects to come into existence, describing a context where cognitive processes are heavily located and influenced by the world-at-hand.

The final thread focuses on the methodological aspects of this study, proposing a dual approach through micro phenomenology and micro ethnography. Whilst the former is presented as a way to highlight the first-person voice in the description of the experience, the latter offers an opportunity to describe the socio-material practices in which the experience is embedded. At the same time, diffraction is presented as an opportunity to read these findings through each other's lens. Finally, this chapter closes by examining the gaps that motivate this undertaking: there is a gap in our understanding of the role of technology in education from the student's point of view that conceptualises digital devices as anything other than tools in order to describe what happens when students and devices come together.

2.2. Entanglement

In the context of this study, Entanglement occupies multiple roles: as a research hypothesis, as an interpretative metaphor, but also as an organisational narrative. This concept traverses this study, from the initial Quantum Mechanics influence of Karen Barad's (2007) performativity to Maturana's (2002) structural coupling. That is why the first part of this chapter is dedicated to providing a definition of Entanglement before the attention is redirected to the main interdisciplinary threads (which will also end up entangled as I weave them throughout the study in order to bring about an explanation of the phenomena). Based on the gap identified in literature, this study constitutes an in-depth investigation of the use of technology in a classroom context.

The issue of technology in education has been researched extensively and from many angles and perspectives. The discussion has become so widespread and varied that it is challenging to get a clear understanding of the current state and to make significant contributions to the field (Biesta, 2016). Whilst the variety of terminologies and the vast volume of the literature make it challenging to review the body of knowledge and identify gaps in the research (Daoud, 2020), the main challenge is that there is no consensus on the underlying philosophy, epistemology, ontology, axiology, methodology, or even the unit of analysis, making the literature incommensurable (Bennett, 2019). Therefore, this literature review does not intend to be exhaustive or all inclusive. Rather, this literature review aims to build a frame of reference for the general discussion and to bring together a number of areas from across disciplines to create an intersecting space, fertile for innovative educational research. Although each of the areas addressed present a rich seam of contributions towards research, there is, I argue, a lack of educational research firmly positioned in the intersection of the fields about to be presented.

In the context of Aotearoa New Zealand, Daoud's (2020) and Bennett's (2019) explorations of the use of technology in the New Zealand classroom had a profound impact on this research.

Daoud (2020) applied complexity theory to gain a deeper understanding of the use of digital devices in the primary school classroom. Her study identified “seven patterns of use that emerged from self-organisation processes” (Daoud, 2020, p. 190). She found that students use devices: (1) as a source of information, (2) means of communication, (3) production medium, (4) external personal memory, (5) collective memory coordinator, (6) trial-and-error learning space, and (7) as a research tool. Bennett’s (2019) research explored the dimensions of the digital artefact and its interrelations with the information artefact in the secondary school classroom using activity theory. Her findings showed that

> when the student uses the technology artefact in a learning action to achieve a purpose the student and technology together can be described as a functional organ: together they are a functionally integrated, goal-directed configuration of internal and external resources. (Bennett, 2019, p. 235)

In both of these studies, technology preserves some form of otherness, it is seen as an external tool (maybe influenced by Cartesian-humanist models). Moreover, neither Daoud (2020) nor Bennett (2019) seem to address the question of what happens when students and devices come together (in the sense of describing the stages, negotiation, and historicity of these encounters). Their studies either describe the use of technology from an instrumental perspective (Daoud, 2020) or focus on how students and devices act as a single organ (Bennett, 2019) but without describing the processes in place for them to come (and stay) together. The contribution of the present study is that learners and digital devices are considered as an entangled entity of distributed agency.

Fawns (2019) argued that as the digital permeates the classroom, it shapes how students engage with information and the very possibility of thinking, due to our entanglement with it and its embedment in the wider culture. I would like to push this idea further and suggest that students are actually entangled with their digital devices. The idea of Entanglement has been used extensively in anthropology (Hodder, 2011, 2012, 2018), neuroscience (Miller & Clark, 2018; Pessoa, 2023), education (Aguayo et al., 2023; Fawns, 2022), and other disciplines. Its use can be traced back to the work of Max Born, Werner Heisenberg, and Niels Bohr, who played a crucial role in formulating the principles underlying quantum mechanics in the early 1920s. In physics, “quantum entanglement is a quantum mechanical phenomenon in which the quantum states of two or more objects have to be described with reference to each other as a single entity, even though the individual objects may be spatially separated” (Zak, 2007, p. 344).

Barad (2007) borrowed this terminology to describe performative couplings. “To be entangled”, they would say, “is not simply to be intertwined with another, as in the joining of separate entities, but to lack an independent, self-contained existence” (2007, p. ix). Human agency, Fenwick et al. (2015) proposed, then becomes a process of manoeuvrability within relational assemblages, as individuals emerge through and as part of their entangled intra-relation (Barad, 2007).

So, what is this digital entanglement? One of the first account of this phenomenon can be found in Mauss' (1954) descriptions of gift exchanges in archaic societies, where he noted that “souls are mixed with things; things with souls” (p. 25), as a way to signal a reciprocity of counter-obligations. Hodder (2012) uses the terms dependences (reliance on) and dependencies (constraints) to describe the dynamic of this reciprocity when he argued that “the social world of humans and the material world of things are entangled together by dependences and dependencies that create potentials, further investments and entrapments” (p. 89). Similarly, in the context of this study, the concept of Entanglement is about focussing on relationality rather than singularity and enquiring into the reliance and constraints emerging form that encounter. Entanglement is about seeing things-in-phenomena, rather than things-in-themselves (Barad, 2003). Entangled properties emerge from the encounter. They do not pre-exist or belong to single components. In this research, Entanglement can be understood as the complex system of engagements, hybridities, and interdependencies amongst human and nonhuman components of phenomena, that create a turbulent river of interactions where agency emerges as a dynamic flow (Barad, 2007).

In line with the first research question of this study (What is the nature of the Entanglement between secondary school students and their digital devices?), this research focuses on Digital Entanglement. Digital Devices, in the context of this study, is an overarching category that includes any electronic devices students use in the classroom (mainly laptops, tablets, and iPads). Therefore, paraphrasing both Barad (2007) and Hodder (2012), Digital Entanglement refers to the system of engagements and hybridities between the students and their digital devices that create potentials, further investments, and entrapments. The purpose of the study is to explore how students and devices come and stay together and how the dance of agencies (Pickering, 2017) is played within the boundaries of this coupling.

In the following sections of this chapter, I describe the four perspectives that act as central threads of this research. First, I briefly introduce how shifts emerging from posthuman and postdigital philosophy require a new interpretation of the education discourse. Then, I pay attention to the fields of technology; cognition and material entanglement, as I explore how they make themselves intelligible to us as an entangled body of ideas whose shifts further affect our current understanding of education. Finally, I will discuss two particular methodologies, micro phenomenology and micro ethnography, that can help us look into these couplings.

2.3. The Philosophical Thread

Mwinzi (2020) argued that "an understanding of philosophy of education is fundamental in a pedagogical process and activity" (p. 122) since selecting one perspective over another have implications not only in relation to the definition of the nature of learning and the nature of education-related concepts, but also in defining the purpose of education itself (Biesta, 2015a). Moreover, in their analysis of the field of educational research, Biesta (2015b) distinguished two philosophical traditions: one that considers education to be a practice dominated by cause-effect relationships, and another that sees education as a human event of communication. In order to discuss those traditions, Biesta (2015b) considers the ontology, axiology and praxeology of education. That is to say, "how education actually works (ontology), the question of what education might work for (axiology), and the question of what this means for making education work and making it work better in the everyday practice of teaching (praxeology)" (Biesta, 2015b, p. 13). However, such level of critical approach is not always the case, since humanist philosophy (or Humanism) has historically been used as a placeholder in education (Ceder, 2020) that highlights what is important and what sits in the periphery. Humanism's main concern has been defining what is human and what is the purpose of man (Giustiniani, 1985). However, its enlightened notions about what it means to flourish and develop have been challenged of late by a number of issues, such as the decentralisation of the human (Braidotti et al., 2016) and the rise of the digital condition (Stalder, 2018), to mention only a few.

This confluence of the question of the centrality of humans and the rise of a society in which social practices are redefined by their links to the digital has an ontological impact on education. It not only brings issues relating to centrality and periphery back in focus but also redefines traditional considerations where agency and intentionality were seen as differentiating aspects of humanness (Copson, 2015). The next few subsections explore two particular ideas, posthumanism and the postdigital, and how they are instrumental in the redefinition of agency. Finally, the last subsection (2.3.3 Dualism versus Monism) presents an alternative view to the dominating Cartesian concepts of "thinking thing" and "extended thing" (*res cogitans* and *res* *extensa*, respectively), which were used to underscore a belief in the fundamental separation between mind and body, a concept known as Cartesian dualism.

2.3.1. Posthuman and Postdigital

The 1982 cover of Time Magazine awarding the title of Man of the Year to a computer – therefore defining 1982 as "The year of the computer" rather than that of a man, which caused a massive uproar among its readership (Badmington, 2003)– most likely marks the introduction of the posthuman into popular discourse. However, the concept has been around for much longer. Going back to 1883's Nietzsche's notion of the overhuman (Sorgner, 2009). Many poststructuralists engaged in decentring projects: from Irigaray (1993) and Kristeva (1991) critiquing male-centered perspectives, to the deconstruction of language (Derrida, 1978) or Foucault (1971, 1976) study of power discourses in society. They all criticised the humanist universalisation of the subject and how such definitions are inherently biased (Ceder, 2020). Towards the end of the last century, a flurry of posthumanist work started to (re)emerge in works such as those of Haraway (1991), Hayles (2000) and Graham (2002).

In philosophy, it can be argued that the posthuman emerges from the convergence of anti-humanism and anti-anthropocentrism (Braidotti, 2019b). The former questions the universal representation of man as *the* human, whereas the latter criticises the species hierarchy that puts the human at the top and everything else below (Braidotti, 2016). Posthumanism offers a new epistemology that by questioning the traditional boundaries between humans, animals, and technology undermines Cartesian dualism and anthropocentrism (Bolter, 2016). This idea of a new paradigm is supported by Braidotti (2013), for whom one of the main aspects of posthumanism is a shift in relation to what constitutes the basic unit of reference for our species. This integrative shift in relation to the other inhabitants of our planet creates a nature-culture continuum that constitutes a new paradigm that distances itself from the social-constructivist approach that still poses a distinction between nature and culture (Braidotti, 2013).

Braidotti (2013) argued that the traditional binary opposition between the given and the constructed is being replaced by a non-dualistic view of the interaction between nature and culture. This new perspective, rooted in monistic philosophy, rejects dualisms and examines how scientific and technological advancements are blurring the boundaries between the natural and the cultural. She defines the posthuman as a nomadic subject, yet firmly situated in a specific context, better understood within the monistic ontological perspectives of Spinoza, Deleuze and Guattari (Braidotti, 2013). Similarly, Ceder (2020) characterised posthumanism as development and a contrast to humanist thinking, a rupture that creates spaces for the resurgence of alternative and indigenous philosophies with notions of agency and possible frames of reference that are less instrumental and more ecological; (Cajete, 2000; Calderon, 2010; Ceder, 2020; Gannon, 2009; Marsden & Royal, 2003; Mika, 2015; Mika, 2012).

The evolution of posthumanism reflects a significant shift in both popular and academic discourse that challenges traditional humanist and anthropocentric views. From early post-structuralists to the more recent works by Hayles (2000) and Graham (2002), posthumanism emerges as a critical framework for understanding the complex interplay between humans, technology, and the environment. It constitutes a paradigmatic shift that moves towards a non-dualistic, monistic philosophy that challenges the boundaries between nature and culture, human and non-human. By redefining the basic unit of reference for our species, posthumanism opens up new possibilities for socio-material approaches (including indigenous philosophies), offering a more integrated and ecological perspective on agency and existence. This ecological understanding also includes the digital.

The term postdigital seem to both refer to a context where the digital has lost all novelty, but also as the digital as a master narrative (Fuller & Jandrić, 2019). It originated in the field of the arts to indicate the humanisation of digital technology by intertwining the digital with other spheres of humanity. Originally coined in 2000 by Cascone (2000) following Negroponte's (1998) idea that the digital revolution is over, because "[t]he tendrils of digital technology have in some way touched everyone" (Cascone, 2000, p. 12), or, in the words of Fuller and Jandrić (2019), because "the digital has lost its novelty or salience" (2019, p. 215). Cascone (2000) suggested that this new postdigital aesthetic focuses on the failures of digital technologies (the glitch, the noise, the error) to remind us that control, and to some extent technology itself, are just an illusion). The postdigital becomes, then, not a state of disruption, but as one in which the disruption has already happened.

For Cramer (2015), however, there is a duality in the understanding of postdigital, since it can be used to refer to a feeling of disenchantment with the intrusive presence of digital gadgets or a historical moment in which this intrusion has become normalised. Ghita et al. (2021) also highlight this dual feeling, pointing out that postdigital hinges in a moment in time when the initial enthusiasm of digitalisation gives way to a critical perspective of it. The "post" in postdigital, therefore, should not be understood as in postmodernism, but rather like in post-punk, post-communism, post-feminism, or post-colonialism: as a continuation that is somehow still a bit of what it 'posts', not a progression but a subtle shift and mutation (Cramer, 2015; Sinclair &

Hayes, 2018). Either way, postdigital thinking rejects techno-positivist innovation narratives — stories or frameworks rooted in the belief that technological innovation is inherently beneficial and can lead to a better future (Danaher, 2022). This sentiment is reflected in Knox's (2019) disregard for the habitual narratives of disruption that often accompany accounts of radical new technologies. since they tend to frame the relationship between technology and society in economic terms, fundamentally highlighting the efficiency of techno-capitalism. The postdigital response emphasises the continuities rather than the novelty (Knox, 2019), focusing on the stories, historicity and enduring aspects of engagement with technology.

Cramer (2015), analysing the resurgence of analogue technologies in contemporary artistic practices, critiqued the uncritical acceptance of digitality. At the heart of the postdigital, he argued, is the issue that while digital devices process information in a disembodied and often sterile manner, our sensory perception remains fundamentally analogue. This disconnection both raises questions about (1) agency and authenticity in digital cultures; and (2) how individuals navigate a landscape where their experiences are mediated by technology. Suggesting that both digital and postdigital practices reflect a crisis in understanding the systems that govern our technologically driven lives, he calls for a nuanced understanding of our engagement with technology. In that sense, the postdigital hinges on the ways and extent to which individuals relate to techno-political realities and reject or identify with their semiotic systems. The postdigital seeks to understand what is new in our relationships with the digital, whilst overtly acknowledging such technology is already embedded and entangled not only with social practices, but also with economic and political systems (Knox, 2019, p. 349).

We no longer live in a world where digital technologies are separated from the natural and social life, but rather in a messy continuum of digital and analogue, biological and informational (Jandrić et al., 2018); not recognising differences between new and old, focussing on the experimental rather than the conceptual (Peters et al., 2018). Similarly, Pepperell and Punt (2000) argued that the term postdigital recognises the current state of technology', while still rejecting shift towards a 'digital revolution', pointing out the need for new conceptual models to describe the continuity whilst avoiding binarism, determinism or reductionism. They propose a metaphor of a postdigital as a membrane that enables a continuity by both connecting and dividing human and technological activity. In its rejection of the reductionism of reality into binary representation, this view is strongly connected to posthumanist ideas, such as Haraway's (1991) feminist cyborg, Barad's (2003) agential realism, or notions of embodiment and education, through its links to the deconstruction of the humanist subject (Jandrić et al., 2018).

In the context of education, Fawns (2019) suggests that a postdigital perspective should encourage a critical understanding of technology and how it is actually used. Similarly, Knox (2019) insists on the same ethical argument when he argues that postdigital education should be concerned with three critical aspects: (1) the economic implications of educational technology as a profit-driven industry; (2) the perpetuation of inequality fostered by the integration of digital tools into educational policy; and (3) the exploitative labour practices and environmental concerns associated with the material realities of technology production. Knox (2019) advocated for an expansion of "the scope of educational research, beyond a tendency to understand technology in terms of tangible devices and gadgets, towards a broader understanding of the socio-technical systems within which the project of education is constituted" (p. 368).

The concept of *postdigital we-learn* (Jandrić & Hayes, 2020) explores this gathering between humans and machines, as a reflection of a recognition that when humans think, reason and make meaning, they do not do so in isolation from the world around them. And even though the world keeps moving towards digitalisation, our educational systems "remain structured towards purely rational, individual progression [that] fails to acknowledge relationships between human beings and living machines and collective learning opportunities" (Jandrić & Hayes, 2020, p. 289). In contrast, *postdigital we-learn* offers a posthuman approach where shared identities are grown concomitantly with the digital systems that are part of our lives, an issue that will be explored in the next section by enquiring into how the confluence of posthumanism and postdigital in the field of education redefines the centeredness and/or peripheral considerations of particular practices.

2.3.2. Relational Agencies

There is a link between postdigital socio-material practices, posthumanism, and agency. Friesen (2018), for instance, linked posthumanist thought to socio-material traditions that trace the end of humanist conceptions in which "humans see themselves as autonomous beings exercising their will through individual agency and choice" (p. 1). Ceder (2020), however, attributed that interest in materiality to posthumanism associations with flat ontologies (Bryant, 2011; DeLanda, 2013), a notion that Actor-Network theory (ANT) refers to as generalised symmetry (Latour, 1987). ANT recognises that the key actants of an actor-network are not always human (Goodwin & Kuehn, 2021), as illustrated by "leave your key at the front desk" program (Latour,

1990) —where attaching a large or heavy keyring to a hotel door ensures that hotel guests leave the key at the door— suggesting that material design can enforce actions and behaviours.

A relevant aspect of ideas linked to generalised symmetry is that, as they challenge the centrality of human agency, they generate a framework in which human agency becomes only “one stream in [the] turbulent river of agencies” (Barad, 2007, p. 239). That is to say, agency becomes a relationship rather than something that someone has; a distributed effect within material webs where humans and non-humans act together to regulate activity. Tara Fenwick (2015) concedes that agency is a problematic term for socio-material researchers, due to its embedded assumptions. Researchers like Orlikowski (2010) view agency as relational and distributed, while Bennett (2020) sees it as emerging from assemblages of human and nonhuman elements. Socio-material studies solve this by focusing on how accounts of agency become stabilised, rather than defining what it is. They see production as an agentic assemblage.

Leonardi (2023) pointed out that agency is commonly defined in reference to three particular ideas and their authors: (1) the “capability to influence one’s functioning and the course of events by one’s actions” (Bandura, 2006, p. 164), (2) the “stream of actual or contemplated causal interventions of corporeal beings on the ongoing process of events-in-the-world” (Giddens, 1976, p. 75); or (3) the “temporally constructed engagement by actors of different structural environments” (Emirbayer & Mische, 1998, p. 970)” (p. xvi). However, in the entangled world of Barad (2007), agency is simply “‘doing’ or ‘being’” (p. 178). Leonardi seemed to support this idea, proposing that agency is a materialisation that does not belong to anyone (human, technology or institutions); instead, it materialises as a relation, as a way to afford or constrain action. Therefore, in a posthuman, postdigital education, agency is not constructed as a conscious intention that mobilises action, but rather as a circulating force that acts through a network of elements interacting with one another in order to get things done (Fenwick, 2008; Fenwick & Edwards, 2010).

Moreover, in a performative context that does not separate doing and being, in an onto-epistemological approach, objects are not first considered as an ontological entity and later described in different ways epistemologically (Ceder, 2020) but is the observation of the phenomena that creates the relata that gives them ontological status. The boundaries of objects are formed through socio-material interactions, involving a performative process where the object is both continuously becoming and a "boundary project" (Haraway, 1988, p. 595), lacking inherent qualities.

Onto-epistemology (Barad, 2007) is a portmanteau of ontology and epistemology. Whilst ontology refers to the study of being, existence, and reality, epistemology is the study of knowledge and justified beliefs. The term onto-epistemology integrates these two philosophical aspects, to emphasise the inseparable nature of doing, being and knowing (Whatman et al., 2023). The concept highlights how our understanding of existence influences our knowledge and, conversely, how our methods and frameworks of knowing shape our perception of reality: in an onto-epistemological framework the knower and the known are not separate entities with fixed properties. From an onto-epistemological perspective, the starting point of educational research and practice is not the entity (subject or object) and their properties but relationality (Ceder, 2020, p. 65). That means that educational interactions are understood as a dynamic and entangled process. In this intra-relational approach, ontologies are flattened: subjects are no longer atomistic units focused on being, but on becoming, on being part of phenomena. In an intra-relational understanding, the properties of the participants impact and saturate each other, thus changing the nature of the interaction. Becoming, therefore, becomes the focus of analysis.

2.3.3. Relational, Ecological and Entangled Learning Perspectives

Within contemporary educational research, relational approaches have gained prominence as frameworks that account for the dynamic interdependencies among learners, tools, environments and practices. These approaches challenge traditional views of individual cognition by foregrounding learning as an emergent property of sociomaterial assemblages. Gourlay (2021), for example, critiques the dichotomy of 'virtual' versus 'real' learning, arguing instead that all digital engagement is materially and bodily situated. She asserts that digital learning is always embedded in a dense network of material artefacts, temporal arrangements, and embodied practices. Carvalho, Goodyear, and de Laat (2017) similarly conceptualise learning as 'entanglement', emphasising how heterogeneous elements such as people, technologies and spaces become intertwined in activity systems. Their framework moves beyond static network metaphors by tracing the fluid and responsive nature of relational configurations that give rise to learning. Relational learning, in this sense, is not about predefined inputs and outputs, but about the co-constitution of agency, meaning and context through ongoing engagement.

Ecological perspectives provide a complementary lens that situates learning within dynamic systems of human and more-than-human actors. These perspectives view educational processes as embedded in nested and interacting systems, extending across spatial and temporal scales. Damşa, Rajala, Ritella, and Brouwer (2023) explore how ecological and posthumanist theories can reconfigure understandings of learning, particularly by recognising the mutual constitution of learners and their environments. Markauskaite, Goodyear, and Sutherland (2023) further synthesise ecological frameworks to theorise learning as distributed, situated and non-linear. They argue for research methods capable of capturing the complexity of educational ecosystems, where learning is enacted through relations among social, material, and affective elements. These ecological approaches open up possibilities for tracing learning trajectories across institutional boundaries, temporal spans, and media ecologies.

Moreover, Kumpulainen et al. (2023) work revealed that students' dialogic encounters with their local environment involved complex entanglements of multiple agencies, including the augmented characters, materials like clothing, natural elements such as trees and forest spaces, and cultural narratives; highlighting the role of relational entanglements across human/nonhuman boundaries. This notion of learning entanglement offers a theoretical articulation of the ways in which learners become caught up in webs of relations that include materials, bodies, technologies and pedagogical scripts. Drawing from Ian Hodder's archaeological theory of entanglement, Yeoman (2015, 2018) develops a conceptual framework for understanding classrooms as sites of material correspondence. Her ethnographic work illuminates how teachers and students become 'caught up and carried along' by the affordances and constraints of educational artefacts, routines, and architectural features. Rather than treating materials as inert backdrops, Yeoman (2015) positions them as active participants in the co-production of learning. This emphasis on mutual interdependence challenges the idea of learner agency as autonomous or intentional. Instead, agency is dispersed and emergent, shaped by the entangled relationships among humans and nonhumans. Yeoman's (2018) contribution is especially significant for posthumanist scholarship in education, as it underscores the need to theorise learning environments as dynamic constellations of interacting forces.

The concept of the postdigital provides an additional framing for understanding contemporary entangled classrooms as hybrid spaces. Forsler et al. (2024) conceptualise the future postdigital classroom as a space of socio-technical co-production, where human and non-human agencies shape educational futures through ongoing reconfigurations. Their work stresses that digital technologies are not external additions to classrooms but constitutive elements of pedagogical and institutional practices. Similarly, Potter (2024) examines students' play as a site of postdigital theorisation. He argues that postdigital play is not merely an activity but a framework through which contemporary experiences of learning, agency and materiality are mediated. Supporting this argument, Woolner et al. (2024) investigate how school spaces manifest postdigital entanglements. Their findings indicate that educational environments are already saturated with digital-material configurations, and that the design and use of these spaces are central to shaping pedagogical relations and possibilities.

The aforementioned bodies of work collectively illustrate how relational, ecological, and entangled approaches have reoriented the study of learning towards sociomaterial configurations and hybrid environments. These perspectives have provided valuable theoretical insights and have begun to influence methodological practices within educational research. However, the present thesis distinguishes itself by adopting an orientation that seeks not only to document these entanglements but to interrogate the onto-epistemological assumptions that underpin them. While relational and ecological models often retain a systems-theoretical or interactionist framing, the aim of the present study is to provide a description not only of the topology of the encounter but also of its landscape, in the form of the hallmarks (or structure) of that experience. In doing so, it contributes to an evolving conversation about what it means to learn, teach, and know in postdigital, more-than-human educational assemblages.

2.3.4. Dualism versus Monism

Ryle (1949/2013) questioned the separation of mind and body, which he called the myth of the “Ghost in the Machine”, and suggested that the mind should be understood in terms of how individuals act and behave in the world. The mind is manifested through observable behaviour, and should, therefore, be understood as a collection of processes arising from the body's complex workings, and not as a separate entity (as argued by Cartesianism). While Cartesian dualism has become ingrained in Western thinking disguised as a common-sensical understanding of human activity (Phillips et al., 2014), there was already in Descartes' time a philosophy that challenged his, namely, that of Baruch Spinoza. Spinoza’s monistic philosophy offers a radical and robust metaphysical alternative to Cartesianism (Dahlbeck, 2016). It posits that there is only one substance in existence, which he calls “God” or “Nature”. This substance, he argued, encompasses both the physical and mental, therefore rejecting the notion of a fundamental separation between mind and body.

Within the cognitive sciences, Damasio (2003; 1994) discussed Spinoza’s ideas of the integration of mind and body, particularly in the context of neuroscience and psychology. He argued that Spinoza’s emphasis on the unity of mind and body provides valuable insights into understanding human emotions, decision-making processes, and consciousness. He draws on Spinoza's philosophy to advocate for an integrated approach to studying the mind-body relationship in cognitive science. Similarly, Thompson (2007) linked the autopoietic concern of the organism to carry on being with the Spinozian notion of conatus (the effort and power of life to preserve itself), and blamed Descartes for conceptualising consciousness as an inner experience accessible only through first-person reflection, and life as an external, mechanical structure. Monism challenges that separation, and in doing so aligns with posthumanist ideas that question the exceptionalism of human beings, and advocates for an inclusive perspective that considers the interconnectedness of all entities.

This section started by presenting that philosophical framework selection shapes what happens in the classroom. By positioning this research on a posthuman, postdigital epistemology this study opens up alternative understandings of what is central and what is peripheral to the educational process, enabling for the emergence of different types of agencies through a relational dance. At the same time, by reflecting on alternatives to dualisms, this study intends to propose a philosophical framework where mind and body are not necessarily considered irreconcilable entities or opposite ends of phenomena, but rather an integrated milieu. This decision applies to embodiment the flat ontologies proposed for the understanding of phenomena and human activity. Finally, by considering flattening ontologies, this study intends to present the viability of thinking about the role of technologies in the lived experience more extensively without reducing it to instrumentality.

2.4. The Technological Thread

Although technology defines us as a species in the sense that humans transcend biology-mechanics dynamics to emerge as hybrids (Stiegler, 1998), materiality is often missing from accounts of educational processes (Fenwick, et al., 2015). This is of relevance if one considers that technological practices have subtle ways to structure our perception (Vial, 2013). Technological practices foster the development of particular kinds of individual and social practices (Mumford, 1955) and of a typified form of perception in a particular place and time (Vial, 2018, 2019). Gille (1986) referred to this phenomenon as technological systems, described as concatenated layers of integrated technological practice, which build on each other. Aviation, for example, integrates layers of practice such as ore mining, smelting, die casting, Oxy-Acetylene welding, epoxy bonding, etc. In the process of developing these layers, each technological systems have the particularity of being developing "certain aspects of the social heritage" (Mumford, 1955, pp. 109-110). Vial (2019) believed that technological systems describe the social structure and identity of an era. In this light, a technological system can be linked to Kuhn's (1962) notion of paradigm or Foucault's (1971) episteme in that they enact a model of reality that defines the conditions of possibility of a time, albeit with the addition of a material-technological layer.

This section of the literature review aims at presenting how conditions of possibility extend beyond material practice and into the very way we perceive and act in the world. The aim of this particular thread is to help contrast the Anaesthetic and Aesthetic paradigms by presenting how particular forms of perceiving and acting in the world present (like the kinds of technologies includes in learning and the role and extension they adopt) in each of them can be traced to their own technological systems. The purpose of this section is not to trace the roots of the present paradigms but to illustrate the way in which technology become a constitutive element of our understanding and presence in the world.

2.4.1. Technological Systems

In the early days of 1960s, Thomas Kuhn published his revolutionary *The structure of scientific revolutions* in which he defined paradigms as "universally recognised scientific achievements that, for a time, provide model problems and solutions for a community of practitioners" (Kuhn, 1962, p. xiii). According to his theory, science evolves in a series of periods in which certain models of reality dominate in relation to procedural problem-solving. These models eventually lose confidence and support and are then replaced by new paradigms. Arguably, an extension of this same idea same, but applied outside the realm of science, can be seen in Foucault's (1971) (re) introduction of the term episteme. He argued that "in any given culture and at any given moment, there is always only one episteme that defines the conditions of possibility of all knowledge, whether expressed in a theory or silently invested in a practice" (1971, p. 191).

The Foucauldian notion of episteme is relevant in the context of this study because it extends the paradigm-shifting approach —similar to what Technological Systems propose— outside the realm of science and technology and positions it squarely in one of socio-material practices. Mumford (1955) proposed that human history is divided into epochs based on technological developments. Most precisely, he used the notion of the machine as the centre of his historiography, dividing the development of civilisation into successive but over-lapping, interpenetrating phases (Strate & Lum, 2000): the eotechnic phase (from 1000 to 1750); the paleotechnic phase (after 1750); and the neotechnic phase at the beginning of the twentieth century. Mumford (1955) argued that technological phases originate in specific regions and use particular resources and distinct methods to create unique forms of production. In doing so, each phase brings into existence specific types of workers, trained in specialised ways. This process, by fostering particular aptitudes while discouraging others, has an impact on particular aspects of the social heritage (Mumford, 1955). Each of the phases' consolidated social practice based on the materials and tools available at the time, developing idiosyncratic skills (Strate & Lum, 2000). For example, people from the eotechnic phase, working with primarily with wood, was able to experiment and enjoyed a high degree of creativity and experimentation, whilst the paleotechnic was defined by mechanisation and industrialisation. This process created a shift from craftsmanship to factories and heavy industries, also creating new social classes.

Gille (1986), criticising approaches to the history of technology too focused on isolated technologies, introduced and approach of technical systems analysis (Dazhi & Högselius, 2015). He believed that technology is usually compound, with single pieces of technology always building to other technologies. These interconnected technological elements can be understood as a technological system. Technological systems describe a set of steps or combinations that, by depending on one another in various ways, lead to the constitution of a determinate form of coherence. These systems are constituted by a series of levels. The first level is called *technical combination*, and it refers to the intelligent and intentional coupling of energy and matter. The second step is called *technical ensemble*, in which a series of techniques combine in a particular production process – for example, that of cast iron (Gille, 1986, p. 14). The last step is called *technical concatenation* and it refers to a product that emerges after a series of stages of production (each of which is a technical ensemble). It is the coherence within these structures is what constitutes what Gille (1986) called a technological system. The pre-mechanical Renaissance system of the fifteenth century and the mechanical industrial system of the eighteenth and nineteenth centuries are examples of such systems (Vial, 2019).

2.4.2. Ontophanic Shifts

Vial (2018, 2019) further explored this relationship between social practices. He proposed a move from technical systems to an ontophanic milieu (Vial, 2019). He argued that prior to their existence as tools in use "technical and technological devices are—and have always been—'philosophical machines', which is to say, conditions of possibility for reality or, better yet, generators of reality" (Vial, 2019, p. 8). Under this light, humans are anthropo-technical entities that depend on technologies to bring the human world into being. Vial (2019) found inspiration in Sloterdijk's (2017) concept of domestication as an intrinsic aspect of human existence. Sloterdijk argued that domestication is not just a historical process but a fundamental anthropo-technical condition; in other words: a "human topology" (Bonaiuti, 2020) that shapes human life. He used the concept of spherology (Sloterdijk, 2011, 2014, 2016) to explain how humans create and inhabit symbolic and biotechnical spaces that enable human flourishing.

Discussing the digital in particular, but technologies in general, Vial proposes a historical phenomenology of technology (2018). He broadened Bachelard's (1931) idea of phenomenon as device dependent, by proposing the concept of ontophany, which Vial (2018) defined as a phenomenological configuration that depends on particular cultural and historical arrangements between techniques and perception. The questions of being and of technology, he argued, "are one and the same (...). The enormous accumulation of tools and processes, know-how and inventions, machines and artefacts create a vertiginous and, as it were, disproportionate whole, whose history coincides with the history of civilization itself" (Vial, 2013, pp. 10-11). According to Vial's (2019) definition of ontophany, the technological aspect involved in this process also includes other phenomena related to technological practices, such as industry, science, and design, as well as social phenomena, such as technology practices, industry, science, and design, as well as the social, because it is "always a network of interdependencies and relationships of mutual involvement" (p. 25). Most importantly, Vial (2018) indicated that technical systems are the highest, most complex concatenations that can be observed in a society, because they embody technological phenomena, and as such they describe the social structure and identity of an era.

Gille (1986) was the first to realise that the technological system that emerged from the endeavours of the second industrial revolution was coming to an end. This mechanical technological system was characterised by mechanisation in order to offload the physical effort from the production process. However, at the beginning of the 1980s, this old model started to crumble and came to an end with the rise of digital technologies: graphical interfaces in the 1980s; the Internet in the 1990s, and Web 2.0 in the 2000s. These new technologies brought forward a new revolution in informatics and networks which Vial, (2019) called the 'digital revolution'. These technologies are establishing a new technological system, characterised by automation which, according to Vial (2018), is as much in its infancy as the first watermill cogs were in relation to the Mechanical System. Volle (1999) argued that in the same way that mechanisation allowed humans to offload the physical work of production, thereby accelerating industrialisation, automation would allow humans to unload the mental effort of production. As Vial (2019) put it, the computerisation of thought (p. 33) is the new mechanisation of the body.

2.4.3. Digital Ontophany

Vial (2019) argued that what the digital revolution really revolutionised is not the kind of objects we perceive (as in introducing new objects) but the actual act of perceiving. Moreover, "perceiving in the digital age is to be forced to renegotiate the act of perception itself, in the sense that digital beings force us to forge new perceptions, that is, objects for which we have no habits of perception. (p. 42). Vial (2019) coined the term *phenomenological revolution* to define the way in which these technologies modify our act of perceiving and thereby affect perceptual culture, since perception is not only a bodily but also a social function. In this way, the digital revolution transcends the limits of historical events to become also a philosophical one in the sense that it affects our phenomenological experience of the world, becoming "a matter of ontology, or rather ontophany, that is, how beings (ontos) appear (phaino)" (Vial, 2019, p. 42). For Vial (2019), technology is an ontophanic matrix (a general structure of perception) since technological constructability is a criterion for phenomenal existence (something needs to be able to come into existence in order to be perceived):

> From one technological system to another, it is not only the object of perception that changes according to the ground-breaking materials that are used (...) or to the invented devices (...). What changes is the act itself of perception in its phenomenological dynamics (p.48).

Technological systems create particular ontophanic conditions, material conditions that determine phenomenal manifestations that are exclusive and particular to it. Vial (2019) identified 11 categories that define digital ontophany, which will be discussed in more detail in Chapter 5, where they are used as a theoretical lens to verify the presence of a first level of digital in the students' stories. The following is a brief introduction to each of them:

1. Noumenality (virtual phenomena only perceivable through an 'interface')
2. Ideality (programmable, synthetic - a patchwork of compilers)
3. Interactivity (not a direct body action but an interaction with a system interface)
4. Virtuality (the capacity of graphical interfaces of creating simulated realities)
5. Versatility (instability - living with the potentiality of 'bugs')
6. Reticularity (a social reality helped and shaped by interfaces' affordances)

7. Reproducibility (instant, infinite copyability)
8. Reversibility (cancelability - the possibility of going back and re-start)
9. Destructibility (‘immaterial’ existence prone to disappear without transformation)
10. Fluidity (light, immediate, simple, ‘magical’)
11. Ludogeneity (playable - explorable)

By extension, these ontophanic categories could also describe the epistemic qualities of our current digital technological system (our current technological system and the successor of the industrial technological system, in which public education was created) and, therefore, have a profound impact on cognition and learning, blurring Cartesian distinctions between the material and the mental (since ontophanic qualities are impacted by the digital). Moreover, Stalder (2018) argued that “in the digital condition, one of the methods (if not the most fundamental method) enabling humans to participate –alone or in groups – in the collective negotiation of meaning is the system of creating references” (p. 59), which “can only become widespread methods if, in a given society, cultural objects are available in three different respects”: economic (affordable), cultural (discursive) and material (usable) (p. 61). The ubiquity of the digital has (maybe for the first time in history) removed most obstacles for the realisation of these three conditions, paving the way for a generalised negotiation of meaning.

2.4.4. Ubiquitous Computing

In the final years of the 20th century, Mark Weiser (1993) suggested that given the trends of unobtrusive technology and increasingly pervasive information, the next phase of computing technology would evolve in a nonlinear manner. He predicted that personal computers and workstations would become obsolete, as computing access would be ubiquitous: embedded in walls, worn on the wrist and scattered around for use as needed. Although his idea of ubiquitous computing seems to have been realised, it might not have been in the way expected. Computing remains far from integrated into our natural ways of embodiment being and moving in the world. The dominant interface format remains the Graphical User Interface (GUI), which has not change much since first developed by researchers at Xerox PARC in the 1970s (Holmquist et al., 2019), and it is dominated by a mainly two-dimensional WIMP (windows, icons, mice and pointers) style of interaction, that is not only what some call a repackaging of the Cartesian desire to transcend the body (Boler, 2002) but also encompasses some level of disembodiment (Ingold, 2024).

However, currently, there are alternatives. Intelligence and perception augmentation have been explored in the field of virtual and extended reality (Davies, 2021), particularly in relation to how Virtual Reality (VR) transforms the way content is delivered by creating a virtual world that allows users to both see and interact with it (Babich, 2019) and offers a fertile field for digital embodiment in education. There is also a particular paradigm that offered the promise to augment the world “by embedding computation into physical objects and environments” (Antle & Wise, 2013, p. 2); however, despite of 20 years of research, it seems to have failed to gain popular adoption. Tangible User Interface (TUI) aimed to enhance the physical world by integrating digital information with everyday objects and environments, pioneered by the metaDESK (Ullmer & Ishii, 1997) it intended to make digital bits tangible. TUI ultimate goal was to couple bits and atoms by transforming digital information into physical, tangible objects as both representations and controls for digital media. These physical objects (manipulable items) were linked with digital elements (such as graphics and sound) through tangible interfaces, creating interactive systems driven by computation but which do not appear as traditional computers (Laštovička-Medin, 2018). TUI had the potential to revolutionise learning by integrating multimodal tools (Devi & Deb, 2017), bringing together visual, tactile and auditory elements seamlessly into a natural interface (Holmquist et al., 2019). A more radical approach that enables both bodily inputs and kinetic interaction is known as Organic User Interface (OUI). OUI are “are non-planar interfaces taking any 3D shape and morphing either actively or passively, to support direct physical interaction” (Nabil et al., 2017).

These design approaches could facilitate the conceptualisation of physical user interfaces that empower humans with multimodal and situated interaction (Kirisci & Thoben, 2018). By weaving digital technology into the fabric of the physical environment, these technologies aim at giving physical form to digital information, “taking advantage of our human ability to grasp and manipulate physical objects and materials” (Ishii, 2008, p. 36), bringing together the industrial and the digital mind, in a syncretic experience.

However, at least one aspect of Weiser’s (1993) ubiquitousness has been realised: Most aspects of social life have become dominated by computer networks, to the point that some argued that Western societies are finding themselves immersed in a new digital condition. Stalder (2018) argued that, from about the late 1960s, institutions of what McLuhan (2011) called the Gutenberg Galaxy —the model of society produced by the changes brought by the advent of the printed book— started to crumble. Unlike Vial (2018, 2019) and Volle (1999), he did not attribute this decline to the engagement with particular forms of technologies, but rather to the emergence of new personal and collective orientations that find a vehicle through the new affordances of the digital. Stalder (2018) recognised two contrasting emerging movements: post-democracies and commons. The former refers to scenarios where large aspects of collective decision-making are moving towards spaces in which a small elite is vastly empowered (such as giant tech and media corporations). The latter refers to the redefinition of personal participation and agency beyond the traditional democratic/political representations. Stalder (2018) suggested that the changes in forms of circulation and generating meaning facilitated by digitalisation have created the conditions for these movements to emerge, since the rise of the digital has fundamentally altered the way we live, work and think, suggesting that we are now living in a digital condition that reshapes every aspect of human life.

He proposes that three key concepts have been instrumental to this transformation: referentiality; communality; and algorithmicity, each offering a lens through which to understand the digital age. Referentiality refers to the way information is interconnected in the digital world. Stadler (2018) argued that digital technologies have created a networked environment where data is constantly linked and referenced across various platforms. This interconnectedness has transformed how we access and process information. In the past, knowledge was relatively static and siloed within specific contexts or institutions. Today, it is dynamic and interlinked, creating a web of information that is constantly evolving. This shift, he argued, has profound implications for knowledge production and dissemination, undermining traditional notions of authority and expertise, as information can be easily tracked and challenged. It also fosters a culture of remixing and reappropriation, where content is continually reused and repurposed in new contexts.

The concept of communality describes the collaborative and participatory nature of the digital age. Stalder (2018) emphasised how digital technologies have enabled new forms of social organisation and collective action. Social media platforms, online communities, and collaborative projects (like Wikipedia) illustrate this trend, demonstrating how individuals can come together to share knowledge, mobilise resources, and create value collectively. Finally, algorithmicity focuses on the role of algorithms in shaping the digital environment. Stalder (2018) examines how algorithms govern many aspects of our digital lives, from search engines and social media feeds to financial markets and surveillance systems. These algorithms are not neutral; they embed specific values and biases that influence the information we see and the decisions we make.

Weiser's (1993) prediction of computing ubiquitousness seemed to have realised; Although it looks like it might be driving cultural and political change, it seems to be leaving the body behind (Ingold, 2024) — at least in relation to natural interaction with the environment—, prompting some calls for action (Abrahamson, 2014; Georgiou & Ioannou, 2019; Paolo et al., 2024; Rajko, 2018).

This section focused on an examination of technology beyond an instrumental perspective and as a phenomenon capable of shaping social practices and perceptions. Human beings are described as hybrid bio-technological being that use technology to bring the world into existence. The technological availability of a particular epoch shape not only socio-material practices but also the negotiations of meaning. It also presented how, as systems dominated by mechanics are giving way to the rise of digital technologies as the dominant form, traditional institutions and ways-of-being are forced to re-negotiate its existence. Two main impacts were identified. (1) that the limited and clumsy ways of sensing and interaction supported by current digital interfaces (Clark, 2011) do not seem to be integrating the fine-tuned sophisticated set of skills acquired by eons of embodied interacting, sensing and manipulating of our environment; and that (2) increasing influence of digital platforms is revolutionising the way information circulates and we make sense of it and, as well as the social practices we construct around it.

2.5. The Cognitive (Shift) Thread

Chapter 1 presented the links of the Anaesthetic School to a particular cognitive paradigm (cognitivism). The main purpose of this section is to complete the Tale of Two Schools by presenting the Aesthetic School paradigm (embodiment). Varela et al. (1991/2017) noted that cognitivism divides the cognising subject into two parts: unconscious symbolic computation and conscious experience, creating a conflict between the computational and phenomenological aspects of the mind. Traditional cognitive theories relied on a computational model of the mind, building representations of an external reality, and prioritising the role that language plays in this process. Barad (2003), however, introduced the notion of performativity to challenge the overemphasis on language and representation in shaping our ontologies. This shift towards a performative approach moves the focus from the accuracy of descriptions mirroring reality to "matters of practices/doings/actions" (Barad, 2007, p. 802). This transition invites us to move away from the brainbound cognitive model (Clark, 2011) and back into the realm of phenomena, also oping up onto-epistemological approaches that highlight not only and integration between doing, being and knowing, but also the inseparable nature of our identity and our ways of knowing (Whatman et al., 2023).

Therefore, moving away from a cognitivist, representational paradigm of cognition into an embodied, perceptually guided one, places further interest in the ontophanic qualities of the digital. Just as traditional technologies transformed the way we interact with our surrounding and social environment; the ubiquitousness of digital technologies is directly and indirectly shaping the global society (Knox, 2019) and has permanently changed our subjectivities (Peters et al., 2018). Digital technologies have become not just the lens through which we perceive social relations and forms of life (Caruso, 2016) but, rather, they have forced us to renegotiate the act of perception itself (Vial, 2019). However, the double confluence in education of the humanist tradition and the cognitive paradigm has contributed to the current consideration of the material aspects of learning (including technologies) as peripheral (Ceder, 2020; Sørensen, 2009).

This section, therefore, will explore how considering cognition as enaction, implies ecological considerations such as the extension of the mind; the importance of action; the development of dexterity; and how all of these layers come together to shape a particular form of lived experience.

2.5.1. Embodied, Embedded, Extended, Enacted

Hutchings (2010) argued that, in the late 1950s, two approaches emerged in the cognitive science: cybernetics and information processing. Cyberneticists like Bateson (1972/2000) emphasised that information loops forming the mind extend through the body into the world, which recognises the roles of the body and environment in thinking. The other approach, information processing, viewed the digital computer as a model for the mind, explaining cognition by reducing it to internal symbolic events and considering the body and its perceptual and motor systems as peripheral. However, Hutchings (2010) further argued, a theory of cognition that excludes culture, context, and history is effectively excluding the study of cognitive ecology, but

> Cognitive science is now returning to these issues. The return is made possible by a combination of advances in understandings of how brains work and increasingly powerful demonstrations of the involvement of body and world in the constitution of the human mind. (p. 707)

For the past 20 years, a wealth of research has provided evidence that cognition (language, reasoning, and numerical processing) is closely linked to sensorimotor systems (Fisher & Coello, 2016). Traditional symbolic and abstract models are challenged by "embodied theories of semantic and conceptual processing [proposing] that access to knowledge requires mental simulations in the brain's modality-specific systems involved in perceiving and acting in the world" (Fisher, 2016, p. 11). These theories tend to question that cognition takes place only in a central system (Fodor, 1983), arguing instead that it takes place also in the perceptual and motor systems (Adams, 2010). Some of them, however, still supporting the idea that it is not totally necessary to abandon the idea that concepts are stored in a non-modal system (Barsalou, 1999; Glenberg & Kaschak, 2002).

Davis and Sumara (2010), from the perspective of complexity theory, also argued against the treatment of knowers and knowledge as a dichotomy that needs to be reunited. They suggest that this dyad is a simultaneity; an idea linked to the self-organisation of living system's notion of autopoiesis, introduced by Maturana and Varela (1974). Moreover, Maiese (2017) pointed out that there is a growing body of literature criticising what Clark (2011) called the brainbound model, which centralises the brain as the main cognitive organ whilst the body is seen as a mere peripheral problem-solver. These critiques, Maiese (2017) argued, come from three specific fields: (1) the extended mind thesis (Clark & Chalmers, 1998); (2) embodied cognition (Gallagher, 2005; Kiverstein & Clark, 2009; Shapiro, 2010); and (3) the enactivist accounts (Colombetti, 2014; Thompson, 2007; Thompson & Stapleton, 2009; Weber & Varela, 2002). In these arguments, the non-neural body (that outside the central nervous system) does not just play a causal role in cognition but rather a constitutive one. It interacts with other parts in such a way that they become an integrated system (Shapiro, 2010). It is only through this system that we engage with the world around us. Our engagement with the world, therefore, acquire particular ways and it is structured according to the particularities of our living body, extending not only to the human experience, but it shapes our experience of self as well (Shapiro, 2010).

Embodied cognition, therefore, can be described as an extension of the functionally connected networks that make up the physical nervous system: the body acts as a dynamic interface enabling neural activity to generate actions that in-turn lead to new sensory inputs (Varela et al., 1991/2017). Knowing, therefore, is not something that happens in spite of the body but, on the contrary, something intimately linked to body and brain actively interacting with the outside environment. In the words of Glenberg et al. (2013):

> Cognition exists to guide action. We perceive in order to act (and what we perceive depends on how we intend to act); we have emotions to guide action; and understanding even the most abstract cognitive processes (e.g., the self, language) is benefited by considering how they are grounded in action. (p. 573)

This embodiment is both “the body as a lived, experiential structure and the body as the context or milieu of cognitive mechanisms” (Varela et al., 1991/2017, p. xii). That is to say, the body is both the interface between us and the world, but also the framework that underpins cognitive structures, as illustrated by what Hutto and Sánchez-García (2015) called attentional anchors. Attentional anchors are the mechanisms used to channel attention during agent-medium coupling (Videla et al., 2021), reducing the operational complexity by bringing motor action as a way to manage complex information invariants. From an embodied perspective, cognitive structures stem from the repeated sensorimotor patterns that allow actions to be perceptually guided (Varela et al., 2016), to the point that Abrahamson and Sanchez-Garcia (2016) argued that learning is moving in new ways

Enactivism extends the concept of embodied cognition by emphasising its dynamic and interactive nature, as well as grounding it in a biological teleology. As Gallagher (2017) noted, enactivism "insists that biological aspects of bodily life, including organismic and emotion regulation of the entire body, have a permeating effect on cognition, as do processes of sensorimotor coupling between organism and environment" (p. 7). Enactivism highlights that cognitive processes are fundamentally about engaging with the world in a particular way. When Varela et al. (1991/2017) published the groundbreaking *The Embodied Mind: Cognitive Science and Human experience*, they intended to bridge the gap between the empirical study of the mind and our lived experience; offering a vision of cognition that is more active, embodied, and embedded. However, by the time their work was published, some cracks were starting to show in the cognitivist paradigm (Ward et al., 2017), particularly around motor control and perceptual recognition. Added to this, findings from the field of connectionism studying dynamical systems were starting to establish that networks can self-organise in order to allow new behaviours to emerge (Rosenblatt, 1958), which required a language able to describe a complex system in action rather than the traditional cognitive talk of representations.

Rosenblatt’s Perceptron (1958) proved that brains can operate on the basis of interconnections in a distributed form, where the actual connections among ensembles of neurons change depending on the experience, a self-organising capacity absent in the cognitivist paradigm. An immediate consequence of integrating self-organising adaptability into a cognitive model implies that including considerations of the environments where cognitive processes develop and operate (Hutchins, 2010). Self-organising adaptability, therefore, introduces both the organism and the environment as equally important variants in the process of cognition, opening arguments towards recognising that the process of defining the mind include loops that extend through the body and out into the surrounding cognitive ecosystem (Bateson, 1972/2000; Clark, 2011).

At the same time, the contributions of ecological psychology, for instance Gibson (1977) highlighted that perception of affordances (understood as relational action possibilities between the organism and an object), were directly linked to the capacities and purposes of the observer. Enactivism emphasises the idea of perception through action and that, although not mindless, cognitive processes are fundamentally shaped by action-orientation. Ryan and Gallagher (2020) summarised the basic tenets of enactivism as follows:

1. Cognition emerges from distributed processes involving the brain, body, and the environment.
2. The world is structured by cognition and action, and it is not pre-given.
3. Cognitive processes are action oriented rather than representational. Meaning emerges from action.
4. Highly influenced by system theory, particularly in the area of dynamical coupling between brain and environment.
5. Emphasis on extended, intersubjective, located cognitive systems.
6. Aim to ground higher cognitive functions in sensorimotor and affective domains of the body.
7. Higher-order cognitive functions are coupled with embodied and situated action

Three main branches of enactivism can be recognised nowadays: autopoietic enactivism (Ward et al., 2017); sensorimotor enactivism (O'Regan & Noe, 2001); and radical enactivism (Hutto & Myin, 2012). Although each present enactivism in different ways, they support some form of continuity between life and mind (suggesting that there is a fundamental connection between living processes and mental processes). In autopoietic enactivism the focus lies on autopoiesis and the continuity between life and mind in which sensorimotor interactions create a teleological directness. Sensorimotor enactivism, however, rejects the strong life-mind continuity. They place their focus on sensorimotor contingencies which enable the use of the environment as an outside memory. Finally, radical enactivism attempts to unify anti-representationalism reacting against cognitivism by focussing on interactive dynamics. However, a larger group of theories can be considered overlapping with the above-mentioned. Although these theories do not identify themselves as fully enactivist, they share to the same extent the idea that the mind is somehow embedded, embodied, extended and/or enacted.

2.5.1.1. Extended Mind.

Nearly thirty years ago, Clark and Chalmers (1998) introduced the Extended Mind Theory, suggesting that the mind extends beyond the brain and body into the physical world. In the foreword to Clark's *Supersizing the mind*, Chalmers stated that the mind relies on the world to function, integrating it as part of the cognitive process (2011, p. 6). Regarding the boundary between mind and world, they propose an active externalism perspective, where the environment plays a crucial role in cognitive processes. Drawing on Kirsh and Maglio (1994), Clark and Chalmers (1998) distinguished between epistemic and pragmatic actions —pragmatic actions change the world to achieve goals, while epistemic actions enhance cognitive functions. Their idea of 'spreading of epistemic credit' suggests that parts of the world contribute to cognitive processes, making these processes occur both in the mind and the world. In this model of active externalism, humans interact with external entities to form a combined cognitive system, in which the removal of these external elements would disrupt the system's functionality. This principle is known as the Parity Principle (Clark & Chalmers, 1998). Clark and Chalrmer's (1998) theory aligns with contemporary perspectives, such as situated cognition and real-world robotics, which already viewed cognition as intertwined with the environment. However, by extending cognitive processes to include external factors, they applied methods typically reserved for internal processes to the external world. One of the main arguments sustaining cognitive processes primarily as internal relates to the portability of these resources: after all, coupled systems can separate. However, although reliable coupling is most likely to happen internally, Clark and Chalmers (1998) argued that it can also happen just as reliably within the environment, which affirms that coupling does not negate cognitive status.

The Parity Principle (Clark & Chalmers, 1998) provides a strategy to avoid bio-chauvinistic prejudice (Clark, 2011, p. 105), emphasising that human minds and bodies are open to deep structural changes, incorporating new tools—both physical and mental—into our cognitive systems (Clark, 2011, p. 50). In other words, the world integrates into our cognitive processes and becomes a part of our minds. In doing so, hominids engage in niche construction and feedback cycles (Laland et al., 2000), altering problem spaces to support thinking and reasoning (Clark, 2011, p. 81). Human minds are not fixed to a single environment but are adaptable to diverse settings. As they reshape their environments, they transform themselves, acquiring phenotypic plasticity alongside genetic inheritance (Sterelny, 2003). These evolving environments reshape our brains, allowing the creation of hybrid cognitive processes that include external tools which qualifies as extended cognition under certain conditions (Clark, 2011, p. 86). Returning to Clark and Chalmers' (1998) original paper, they listed four criteria for non-biological elements to be part of an individual's cognitive system: (1) reliable availability, (2) automatic endorsement, (3) easy accessibility, and (4) conscious endorsement. The concept of the expanded mind provides further support for the notion that cognition involves both the environment and the body. Moreover, it establishes the physical basis of the mind not confined to the head alone (Clark, 2011, p. 102), but extending into the world we inhabit.

2.5.1.2. The Primacy of Action.

Autopoiesis originates in the work of Humberto Maturana and Francisco Varela (1974). It refers to the self-organising and self-maintaining nature of living systems. It emphasises the self-creative nature of living systems, where the components of the system are continually produced and regenerated through their interactions and transformations. These components, in turn, contribute to the maintenance and realisation of the overall network of processes that constitute the system. Autopoiesis is characterised by a circular and self-referential organisation that enables the system to maintain its identity and integrity over time. Francisco Varela was one of the authors of *The embodied mind.* The book is considered one of the foundational works of enactivism and draws heavily on the phenomenological work of Merlau-Ponty (1962).

Understanding cognition as a property of living systems implies considering the interactions of the organism within a dynamic relationship. The body, therefore, should not be regarded as a simple biological unit, but as the structure of our situatedness and experience within the world. Perceiving, therefore, is not a question of inner mental states, but of being "familiar with, deal[ing] with, and find[ing] our way around in an environment" (Carman, 2012, p. x). It is in this disposition towards the environment that Merleau-Ponty situated intentionality, rather than in relation to linguistic expression. For Merleau-Ponty, was an often-unconscious bodily skill and disposition towards the word: skilful bodily responsiveness. These intentional attitudes are not just sensorimotor capacities, but modes of being in the world. In Merleau-Ponty's words:

> My body is geared into the world when my perception provides me with the most varied and the most clearly articulated spectacle possible, and when my motor intentions, as they unfold, receive the responses they anticipate from the world. This maximum of clarity

> in perception and action specifies a perceptual ground, a background for my life, a general milieu for the coexistence of my body and the world. (Merleau-Ponty, 1962, p. 261).

In other words, when our perceptions and actions align, they establish a stable basis for our existence, acting as the backdrop for our lives and facilitating a seamless coexistence between our body and the world around us, highlighting the crucial role of the body in shaping our experiences and understanding of the world. Although Merleau-Ponty does not see perception as a mode of thought, he describes it as the form that grounds all human experience and understanding. Perception has two essential aspects: the passivity of sense (sensory dimension) and the activity of body skills (motor dimension). These aspects are interwoven and inseparable aspects of a single phenomenon: "The phenomenal field is neither caused nor defined but constituted by the sensorimotor structures and capacities of the body" (Carman, 2012, p. xv). Being, therefore, is synonymous with being situated. The body exists both as a thing in space but also as a system of possible action (Merleau-Ponty, 1962).

Gibson (1966) also argued that perception is an active process. The organism directly perceives action possibilities, or affordances, in the environment. Perception, therefore, is not just passively receiving sensory input but perceiving opportunities for action. This process, however, is not unidirectional, since "we must perceive in order to move, but we must also move in order to perceive" (Gibson, 1979/2014, p. 213). This idea is also reflected in Varela et al.'s (1991/2017) proposal that meaning is co-constituted through embodied interaction with the world. In lived cognition, the "sensory and motor processes, perception and action, are inseparable. They are not contingently linked, but they have evolved together" (Varela et al., 1991/2017, p. 173), that is to say, perceptual experience is not only active and dynamic but also integrated into sense-making.

This interconnection between perceiving and doing (and even between doing and being) is mirrored in the work of Karen Barad (2003, 2007) and their onto-epistemology approach (as explored in Section 2.3.2). Barad (2007) proposed agential realism as a theoretical framework in which there is an epistemological inseparability between both observer and observed, but also between the observer and the measurements resulting from that observation due to the ontological inseparability between the entangled agency of the components (intra-acting). Therefore, understanding phenomena as the constitutive of reality implies accepting that reality is composed not of isolated things with their own properties, but things-in-phenomena (p. 140), whose boundaries and properties are only determinate within the phenomenon (Barad, 2007). In this framework, agencies do not precede the interaction but, instead, they emerge as a result of this intra-action, bringing together discursive practices and the material world. Being, therefore, becomes intrinsically linked performative entanglements of interpenetrations. Moreover, going back to Spinoza's monist philosophy, it can be argued that both Spinoza and Merleau-Ponty propose that knowledge and understanding are gained or shaped through our bodily interactions with the world.

2.5.1.3. Dexterity

In this active, cognitive interaction with the world, the dynamic coupling interdependence between action and perception can also be mapped at the level of the embodied interaction with that environment. Related to this point is Bernstein's (1996) notion of dexterity, who argued that motor control requires a dynamic perceptive relationship between proprioception (the states of the body) and exteroception (the exterior world) (Ito, 2011). Bernstein's original definition of dexterity, which would later be absorbed into what we now recognise as motor control studies, described it not as a property of movement that can be found in the motor act itself, but rather as an interaction with a changing environment (Bernstein, 1967; Bernstein, 1996). That is to say, "a property of movements in situations" (Reed & Bril, 1996, p. 432).

In contrast with dominant ideas of the time, Bernstein did not base his theory on movements as building blocks (as many of his contemporaries did) but on action. He proposed that "absolute repetition of a movement pattern is not possible because of the inherent variability and complexity of the environment" (Reed & Bril, 1996, p. 435). In this sense, his work is connected with that of Gibson's visual world (1950), as both developed a "ground" theory rather than an "air" one (Latash & Latash, 1994; Reed & Bril, 1996). Both Bernstein and Gibson's theories were heavily contextualised within the environment of the organism. Physical dexterity, therefore, refers to the ability of the human body to perform skilled movements efficiently and accurately by overcoming the excessive degrees of freedom problem (Bernstein, 1967; Latash & Latash, 1994).

The human body possesses a large number of redundant degrees of freedom (Bernstein, 1967), meaning that there are multiple ways in which a particular movement can be executed. However, not all of these possibilities are equally efficient or effective. Physical dexterity, therefore, lies in the ability to select and coordinate the appropriate degrees of freedom needed to achieve a desired movement goal. The senses are the instrument through which the organism can overcome those excessive degrees of freedom by introducing sensory corrections. This idea of multiple levels of control of movements and a hierarchy of feedback loops was revolutionary for its time (Latash & Latash, 1994). This regulatory understanding of repetition, which is a form of feedback loop, has the ecological function moderating the degree of freedom by providing small variations that allow the individual to adapt to different conditions and refine their motor skills. Moreover, motor skills are defined ecologically as "the ability of an organism to encounter the range of environmental variations for a given motor problem and to learn to solve them adaptly" (Reed & Bril, 1996, p. 436). From a current understanding, it could be argued that his theory includes aspects of system organisation, in that repetitions are chosen only in relation to their contribution towards the overall stability of the system.

Linking the work of Bernstein (1967) in physical dexterity and that of Gibson (1977) in ecological psychology and affordances, Reed and Bril (1996) proposed a theory of cultural ecology for human action development. In this model, our ecological niche as a species (understood as a set of opportunities for meaningful action or affordances) is constantly influenced by our interactions with others and their behaviours attracting attention to particular affordances. This creates a selective opportunity for action, named "field of promoted action" (Reed and Bril, 1996, p. 439), which can be organised according to particular cultural characteristics. For example, in different cultures, the way people perform everyday tasks (carrying loads, sitting, dancing, etc.) can vary significantly. These variations are influenced by the cultural context, which promotes certain actions and motor skills over others (Abrahamson & Trninic, 2015). Since the process of mastering physical dexterity is to problem-solve, these cultural delineations of promoted action (scaffolding) create an extra level of complexity when it comes to action in context. All of these arguments reject the idea of a detached, contemplative observer and emphasise the active engagement of the embodied organism in perceiving and knowing, even when —it can be argued— that engagement is with the digital.

Moreover, Rietveld (2014; 2017; 2013; 2018) understood affordance-responsiveness as a central feature of everyday skilful activity. His Skilled Intentionality Framework (SIF) argues that the acquisition of human abilities reflects a historicity of interactions within sociocultural practices (2018). That is to say, a skilful organism responds selectively and adequately to particular affordances (Rietveld, 2008) in a context-sensitive way. His work is based on Merleau-Ponty's (1962) notion of tendency towards an optimal grip and its subsequent refinement by Dreyfus (2002), culminating in the idea that, in a skilful activity, the situation solicits the organism to find an equilibrium with it (Rietveld, 2017). SIF connects notions of a number of independent fields such as: (1) affordances (from ecological psychology); (2) embodied responses (from embodied cognitions); (3) response to multiple affordances (from phenomenology); and (4) affective states (from affective psychology) to develop a theory in which "action readiness is a bodily phenomenon in-between overt action and ability, a form of action preparation" (Rietveld et al., 2018, p. 55).

2.5.1.4. Lived Experience

It can be argued, therefore, that all of these ideas find a fertile ground in the field of enactivism. Moreover, from an enactive perspective of cognition, the notion of lived experience becomes central to the study of cognitive processes, since it fundamentally challenges the traditional views that separate the mind (and therefore higher cognitive functions and consciousness) from biological existence and life processes.

The notion of lived experience originates in the field of phenomenology, and it relates to the nature of experience from the point of view of the person experiencing the phenomenon. This term comes into English from German, where the noun *Erlebnis* was coined from the root verb *erleben* meaning "to live, to see". This original term had a twofold significance: a) what one experiences for oneself; and b) its lasting residue. "Er-lebnis would mean more literally what unfolds and endures from life by virtue of life itself" (Burch, 1990, p. 131). The term was introduced into academic discourse to differentiate between being alive (i.e., *Leben*) and the people's live experience (i.e., *Erlebnis*) (Dilthey, 2002). Burch (1990) commented that

> The fact that the expression 'lived experience' [in English] sounds to us tautological may be taken as a preliminary indication that its lived quality is of the very essence of experience and in some vague average way is always already understood within experience itself. (p. 133)

The Heideggerian (1927/1996) term Dasein (being-there) emphasise the situatedness and contextuality of human existence (being-in-the-world). This idea that we always find ourselves in a world that is meaningful and structured by our interactions and engagements presents similarities with another term: *Umwelt*, introduced in 1934 by Jakob von Uexküll. The word, which translates from German as "environment", has been widely used to refer to the perceptual environment of an organism. This perceptual environment might be perceived differently by different species. It refers to the subjective world that an organism inhabits; a world that is shaped by its sensory perceptions and experiences (Von Uexküll, 1934/2013), highlighting a move away from the mental representations of the cognitive paradigm into a located, enactive understanding of the process of cognition. Ward (2017) pointed out that the main difference between cognitivism and enactivism is that

> Whereas the cognitivist holds that significance (or meaning) is bestowed by the organism representing environmental structures in the service of adaptive behaviour, [enactivism] argues that significance is enacted as part of a dynamical process that creates and sustains both the organism and the environment to which it is responding. (p. 368)

That is to say, while for cognitivism the organism perceives in order to create an internal mental model of an external world, for enactivism perception enacts both the observer and the environment. They emerge together. This dynamical process, based on the lived experience, depends not only on the particular embodiment of the organism and the locality of that environment, but it also includes the complex milieu of interrelations amongst them. Lived experience, therefore, becomes a phenomenon closely related to subjectivity (a more detailed account of this process is presented in Section 2.7.2.1: Micro Phenomenology).

Our lived experience, therefore, is constituted by a multitude of dimensions attuned to our inhabitation of particular contexts. The body, from this perspective, ceases to be just a biological mass to become our main interface with the world and the substrate where cognition is anchored. However, another important aspect of this dynamic of understanding cognition not as a brainbound representational and computational process requires consideration of the interactions between the embodied self and the material world around it.

This section explored the shift from the traditional cognitivist paradigm (the Anaesthetic School's), which emphasises symbolic computation and representation, to an embodied and enactive approaches (The Aesthetic School's), which advocates for an ecological perspective. This enactive understanding emphasises the dynamic, interactive nature of cognition and its grounding in biological teleology, and therefore in an ongoing and active dynamical coupling with the environment. The interactions with that ecosystem are presented as impacted by particular forms of dexterity developed in context. Moreover, certain cultural characteristics shape this dexterity, by creating the field of promoted action, within which our unique lived experience emerges as a result of both by biological and cultural milieu. The next section looks into that material entanglement not only between the body and the objects 'out there', but between agencies and cognitive processes.

2.5.2. Deep Learning: From Progressive Education to Embodied Practice

One of the most problematic areas to research for this study has been that of deep learning. The issue hereby lies not only in the association of this term with machine learning and neural networks, but also in the lack of common language to address it. However, one of the main challenges when identifying deep learning approaches was the navigation of those based on cognitive (rather than enactive) principles. Seminal work regarding deep learning include Dewey (1938), Piaget (1952), Vygotsky (1978), Bruner (1971), Kolb (2014), Gardner (Gardner, 1983), Bloom (1956), Hattie (2009), Ericsson (1993), and Perkins (Perkins, 2008), to name some. This section aims at discussing how a theory of deep learning is not complete unless it explicitly accounts for the role of the body. Given the complexities expressed above, it is imperative to include here a brief overview of the main theories that inform this discussion.

One of the early transformative ideologies in education (the New Education movement) started in Europe towards the end of the 19th century. Based on the work of Herbart's (1896) five steps (preparation; presentation; association; generalisation; and application), it argued that students should be taught to ask questions and think systematically rather than engage in rote learning. In America these ideas were continued under the name of Progressive Education, reflected by Dewey's work on learning by doing. One of Dewey's foundational ideas was to tap into the learners' life experience and cultural background, promoting active rather than passive learning by activating learners' interest.

Years later, Vygotsky (1978) and Piaget (1953) highlighted the importance of understanding that the intellectual and emotional development of learners occurs in discrete stages. Their contributions helped dispel the notion of the learner as an empty vessel that needed to be filled in exchange for a theory in which the learners build their knowledge through social engagement. A student's approach to their learning depends on their perception of the task ahead; their motives, and the immediate context in which the task is presented. Students' learning approaches can be categorised as into surface, deep, and achieving approaches to learning (Biggs, 1988). Students' adoption of one approach over another is determined by their expectations of what is required of them (Marton & Säaljö, 1976). In this framework, the surface approach is characterised by memorisation or application without reflection; whilst the deep approach is characterised by an intention to understand and impose meaning (Smith & Colby, 2007).

From the perspective of knowledge (rather than learning), it is possible to identify three types of knowledge: surface, shallow and deep. Surface knowledge is predominantly information; shallow knowledge is information and some understanding and sense-making; and deep knowledge requires understanding, meaning, and integration. That is to say, deep knowledge requires a shift one's frame of reference as the context shifts (Bennet & Bennet, 2008). Most importantly, there is a correlation between the different levels of knowledge, learning, and action: Whilst at surface level, the focus is on facts and data that can be either memorised, applied, or captured and stored in technological systems; at a shallow level, the focus is on social interactions such as conversations, debates or interactions with communities and teams. Finally, at the deep level "the focus is on the learning from effortful practice and lived experience" (Bennet & Bennet, 2008, p. 13), that means that deep learning occurs when individuals actively engage in challenging practices. This process of action, reflection, and adaptation leads to a deeper understanding and a more effective application of knowledge and skills.

Deep learning, therefore, can be facilitated by pedagogies specially designed with this outcome in mind, in line with learners' core motivation and doing things that make a difference to their lives and the world (Fullan et al., 2014). And it is maybe this creation and use of new knowledge in the world that allows for the formation of links between deep learning and lived-experience. Moreover, digital technologies have unleashed the potential for learners to explore and apply knowledge outside of school, in the real world of their daily experiences" (Fullan et al., 2014). However, students seem to have two files: the course file and their life file (Fink & Fink, 2013). In order to build significant learning, therefore, educators should draw on learners' own life experience and link it to their future experiences.

2.6. The Material Engagement Thread

This thread can be seen as a corollary from the previous three sections. The Philosophical Thread introduced a decentring perspective where the human no longer tops pre-existing hierarchies but rather becomes an intertwined entity in a network of flowing agencies. In this performative context, being, doing, and knowing cannot be separated, explaining the onto-epistemological perspective chosen for this study. The Technological Thread furthered this argument by delving into the role of technology in shaping social practices and subjectivities. Moreover, it presented how the ubiquitous presence of digital devices is changing our modes of perception and action, as they have become philosophical machines. Finally, The Cognitive

(Shift) Thread presented how the cognitivist paradigm (imbued with metaphors of its own technical system) seems to be giving way to a more embedded, enactive paradigm where not only the body but our very being in the world becomes of paramount relevance. In this section, the focus is on material engagement with the world. It presents how our interactions with the material world, far from utilitarian or gratuitous, become intrinsically entangled with our cognitive processes.

2.6.1. The Explanatory Gap

In philosophy of the mind, the explanatory gap refers to the difficulty of explaining how subjective experience arises from physical processes. Famously, Chalmers (1995) distinguished between a hard and an easy problem. He argued that even if we were to solve all the easy problems and understand the brain's functional aspects completely, there would still be an explanatory gap in comprehending why and how these physical processes give rise to subjective experience. However, as will become clear in this section, there still seems to be an explanatory gap in regard to "[w]here do we draw the boundaries of the mind with respect to body, materials and techniques" (Malafouris, 2021, p. 108), particularly when (1) it relates to the use of digital devices in the education; and (2) when it comes to define the boundaries of the learners sitting in front of us.

Between the notion of basic minds without content (Hutto & Myin, 2012) and the "deep integration between brain, body, and cognitive tools" (Menary & Gillett, 2022, p. 1) there is a vast territory seldomly explored (Malafouris, 2021). A rich body of literature explores the links between embodiment and our understanding of the world (e.g., Lakoff, 1980; Lakoff & Johnson, 1999); "basic" cognitive processes (e.g., Hutto, 2012; Hutto & Myin, 2017; Hutto & Sánchez-García, 2015); knowing by doing (e.g., Ingold, 2013, 2022a, 2022b; Malafouris, 2012, 2013, 2015, 2021); and artefactuality (Hutto, 2012; Menary, 2007; Menary & Gillett, 2022; Sanches de Oliveira, 2022). However, a clear description of how material engagement with digital devices shapes and impacts high level cognitive processes in natural, open environments is – to the best of my knowledge – still missing.

2.6.1.1. Thinking with Things.

Tim Ingold (2011/2022, 2013), echoing the language of Bateson (1972/2000), used the expression material ecology to refer to the study of the mind in context. Similarly, Malafouris' (Malafouris, 2013) Material Engagement Theory (MET) also aligns with ecological and enactive epistemologies. However, from the perspective of MET, any dissociation between the organism and the environment that is asymmetric becomes incompatible. MET's main objective is to demonstrate that it is possible "to think through things, in action, without the need of mental representation" (Malafouris, 2004, p. 58). MET is a theory that aims to replace the prevailing internalist idea of a representational mentality that uses the body to preform mental plan via material means. It offers, instead, an enactive and dynamic perspective of participatory mentality. In this view, bodily actions and material affordances not only execute but also generate and shape thought processes.

Although MET aims at grounding representation on enactivist foundations, it does not necessarily commit to non-representationalism. However, form the perspective of MET, thinking does not happen inside brains, bodies, or things; instead, it emerges from processes *between* brains, bodies, and things (Malafouris, 2013). MET is constituted by three main working hypotheses: the extended mind, the enactive sign, and material agency (Malafouris, 2013), all of which are described in the following sections.

Although recognising their individual theoretical differences, Malafouris (2013) grouped extended cognition, distributed cognition, embodied cognition, embedded cognition, mediated cognition, enactive cognition, dynamical cognition, and situated cognition as strands that move away from cognitivism and towards embodied action-taking between the organism and the environment. As a way to overcome the combined limitations of these theories, Malafouris (2013) proposed the hypothesis of the constitutive intertwining of cognition with material culture, according to which "material culture is potentially co-extensive and consubstantial with mind" (p. 77), that is to say, mind and things are not causally linked but constitutively interdependent, not being able to exist without the other. Thinking, therefore "is not something that happens inside brains, bodies, or things; rather, it emerges from contextualised processes that take place "between" brains, bodies, and things" (Malafouris, 2013, p. 78). From the standpoint of MET, cognition becomes not a within but a between property.

Departing from the premise that "from a semiotic perspective, language and material culture differ substantially in respect of the cognitive mechanisms that support their semiotic function" (Malafouris, 2013, p. 91), Malafouris argued that the material sign embodies an enactive logic rather than a communicative one. This means that" for material semiosis, meaning is not the product of representation but the product of a process of 'conceptual integration' between material and conceptual domains" (Malafouris, 2013, p. 91). The material sign does not stand for a concept but rather it substantiates a concept as physical forces that shape the social and cognitive landscape. Therefore, enactive signification is the crux of material semiosis**.** That is to say, the process involves a dynamic relationship where both the signifier (the material object) and the signified (the concept or meaning) emerge simultaneously through their engagement (Iliopoulos, 2019).

2.6.1.2. Physical Objects.

Malafouris proposed the notion of cognitive projection as a mechanism for dense structural coupling between mind and matter. Cognitive projection can be defined as "the pervasive and (in most cases) unconscious capacity of the cognitive agent to establish direct implicit ontological correspondences between domains of experience" (Malafouris, 2013, p. 100); that is to say, cognitive projection is the sort of conceptual mapping that allows the emergence of a pre-intentional background that constitute a basic cognitive mechanism though which we make sense of things. What differentiates projection from mere perception and imagery is the need for an external, manipulable structure; that is to say: material anchoring (Hutchins, 2005; Hutchins, 2008; E. Hutchins, 2010). Cognitive projection allows for the emergence of a "hybrid assembly" (Malafouris, 2013, p. 104) with emerging meaning, since physical relations (material anchors) can be proxies for conceptual relations (Hutchins, 2005).

It is through these embodied engagements and assemblages that the mechanisms for reasoning, imagination and abstraction are created (Goodwin, 2010; Edwin Hutchins, 2010); and not, as cognitivism would have us to believe, in the isolated brain. This salience of engagements in the process sense-making is similar to that presented by Petitmengin (2021) in relation to the micro-gestures. Her theory suggests that our modes of relating to the world create different types of experience architectures from where ideas arise. Or, back in Malafouris' (2013) words, "cultural things provide the mediational means to domesticate the embodied imagination" (p. 106). The main difference, however, is that whilst Malafouris emphasises the role of culture; Petitmengin sees it as an obstacle, in that the preconceptions emanating from it distort our perception of the experience.

The material sign, Malafouris argued, rather than being a passive conduit or message, provides the basis for the enaction of semiotic processes by defining phenomenological modalities: it operates both as a signifier and a signified. However, meaning does not reside in the material sign, rather, it emerges from being engaged with, affording possibilities of meaning (p. 118). This material entanglement cannot be disentangled, because "while agency and intentionality may not be properties of things, they are not properties of humans either; they are the properties of material engagement" (Malafouris, 2013, p. 120). Accepting this requires deviating from a traditional, anthropocentric view of agency (Giddens & Pierson, 1998) and adopting a more decentralised notion one, like that argued by Gell (1998) and Latour (1990, 1992, 1993, 1999) or the ANT framework that view agency as distributed and relational (Law, 1999). In this material-semiotic framework, there is no meaning, only contexts (Malafouris, 2013), where intentionality and agency are not properties of the human but that of a chain of associations. However, Malafouris (2013) warned that the agency of things should not be considered as an isomorphic projection, because even though in material agency objects are seen as active, they are so in a manner that differs to that of people.

2.6.1.3. Cultural Artefacts.

One of the main challenges to the concept of material agency comes from the notion of intentionality. If a theory of agency is constructed around intentionality, then agency must be a human property, since objects do not have intentionality (Malafouris, 2013). However, Malafouris, following Searle's (1983) description of activity which differentiates prior intention (state of mind) and intention in action (action in the world), bridges this gap by introducing the notion of pragmatic effect. Pragmatic effect "is not a matter of private thought and imagination but a matter of actual practice and being in the world" (Malafouris, 2013, p. 140). That is to say, prior intention is realised in the world in the form of intention in action. However, not all intentions in action are the result of prior intention (Searle, 1983) nor the former necessarily determine the nature and form of the latter. However, and most importantly, it will be the qualities of the background (Searle, 1983) what shapes the intention in action, transforming agency into a property of people and things as an attribute of extended cognition.

Malafouris' work relates to others that see the interaction between the organism and their environment as a recursive, dialectical phenomenon (e.g., van der Schyff & Schiavio, 2017). Tomlinson (2017) referred to this process as biocultural coevolution, which is characterised by the presence niches and cultural epicycles. A niche, in a cognitive sense, can be described as a stage of cognition (Tooby & DeVore, 1987) or as the externalisation of knowledge into the environment to alter the selective pressures that an organism encounter (Pinker, 1997, 2010). Cultural epicycles (Tomlinson, 2017), on the other hand, is a particular modification of niche construction, in that the changes impacting the niche are no longer external (e.g., climate) but internal (human activity), bringing about new constraints and affordances. These cultural epicycles occur within the milieu of the organism and guide developmental processes that are then fed back into the environment, impacting the niche and, therefore, the organism once again. The making of tools, which can be extended to conceptual artefacts (Raja, 2018, 2019, 2021) is often presented as an example of said epicycles (Malafouris, 2004, 2013, 2015; Tomlinson, 2017). Thus, some forms of thought originated, developed, and were stabilised through the dynamic interaction between living systems and the material environments they inhabited and shaped (Ingold, 2000/2021). Furthermore, two important concepts from the work of Tim Ingold also might be seen as contributing to support the salience of digital ontophany: that of dwelling and correspondence.

Ingold (2000/ 2021) introduced the concept of dwelling as an exploration of fundamental aspects of human living and its ways of being in the world. For Ingold, the interconnections between individuals and their environments and the skilful engagement with the world are of particular importance. Ingold's work has strong links to that of Gibson (1977) and Bateson (1972/2000), arguing that the mind resides out there in the world and not inside the head. Ingold, therefore, paints a picture of a complex world where human beings are constituted simultaneously as organisms within ecological relations, and as persons within social systems of relations, not as two types of different relationships but as one and the same. Moreover, Ingold (2000/2021) argued that there is a parallelism between developmental critiques of neo-Darwinian biology and ecological psychology, in that both object that what an organism does is the result of intelligent design. He suggested that the human being is a "singular locus of creative growth within a continually unfolding field of relationships" (Ingold, 2000, p. 6). In this vision, cultural variations take the form of skills, understood as the capabilities of action and perception located in a structured environment. They are not transmitted, but regrown and incorporated through training and experience, via what Gibson (1979) referred to as "education of attention". From this particular understanding of skill emerges his notion of dwelling, which situates the individual in active engagement with its surroundings, where social relations are nothing but a subset of the ecological.

Unlike Bateson (1972/2000), who differentiated between an ecology of the mind and an ecology of energy and material exchanges, Ingold offered a rethinking of life where form and process are organically intertwined. Life, therefore, "is not the realisation of pre-specified forms but the very process wherein forms are generated and held in place" (Ingold, 2000/2021, p. 22). An important clarification is that "my environment is the world as it exists and takes on meaning in relation to me, and in that sense it comes into existence and undergoes development with me and around me" (Ingold, 2000/2021, p. 23). That means that the totality of the organism plus environment also includes time. It is a process that unfolds and that is constantly under construction, which connects with the micro phenomenological understanding of experience (Petitmengin, 2017) and the posthuman understanding of subjects as constant becomings (Braidotti, 2013).

A particularly interesting contribution from Ingold (although he takes it from Anderson, 2000) is the idea of sentient ecologies, a form of ecologically constructed embodied action-readiness that Ingold (2013) described as the skills, sensitivities and orientations that humans develop through long experience and life within a particular environment. They are a pre-objective and pre-ethical intuitive and perceptual engagement with their environment. They allow us to, as Ingold (2013) says, to learn by growing into the things we want to learn and letting them grow in us. Knowing, therefore, becomes a process of active following, what Bateson (1973) called deutero-learning, a kind of learning that allows humans to be taught by the world. This idea is the base of Ingold's (2013) notion of correspondence. Correspondence is intrinsically linked to making and acting in the world. "In the act of making", Ingold says, "the artisan couples his own movements and gestures – indeed his very life – with the becoming of his materials, joining with and following the forces and flows that bring his work to fruition" (Ingold, 2013, p. 31). That is, we experience ourselves as moving and being moved in a cycle of on-going response. In this, Ingold (2013) seems to agree with Barad (2007) who argued that "humans (like other parts of nature) are of the world, not in the world, and surely not outside of it looking in" (p. 206). Understanding human practice as an act of dwelling and making as correspondence means embracing not particular forms of being in the world, but accepting that we are of that world; part of a single phenomenon and inter-penetrated with each other's properties. In other words, we are in that world and that world is in us too.

2.6.1.4. Bio-Cultural and Socio-Material Entanglement.

Arguably, human social cognitive studies have captured the attention of academic disciplines since the rise of the Social Brain Hypothesis (SBH) (Barton & Dunbar, 1997) in the late 90s. However, it has been in the last decade that criticism has mounted about its prevalent Cartesianism in regard to its linkage to the cognitive paradigm (Barona, 2021). At the same time, the increasing attention to material engagement (Ingold, 2022a; Kirmayer et al., 2020; Malafouris, 2013) has brought about a renewed interest in the nature and location of the mind and the role of the material world. Stade and Gamble (2019) argued that objects and artefacts are not passive tools but active participants in the cognitive processes of humans. By engaging with them, individuals are drawn out of their isolated mental worlds and into a collective space where shared experiences and meaning are created. This idea aligns with Hutchins (2008), who highlights the importance of cultural practices in shaping cognitive processes (also known as distributed cognition). These practices play a crucial role in organising and coordinating distributed elements. By engaging in cultural practices, individuals can harness and integrate various cognitive resources, leading to the emergence of complex cognitive outcomes, therefore challenging the idea of cognition as a solely internal process.

Take, for example, writing. Overmann (2021) points out that literacy implies a suite of behavioural and psychological changes that emerge as result of an interaction with a particular material form (i. e., fine motor movements; topological recognition; recall functions; eye-hand coordination). Its sustained collective use and its capacity to be malleable enough to change reflects an accumulated and distributed cognitive effort which influences behavioural and psychological change between individuals and generations (Overmann, 2021). Menary (2007), famously described writing as thinking in action, in which manipulating written vehicles, either pen and paper or electronically, is a kind of problem solving that requires external vehicles in order to maintain behavioural competence (i.e., a long division or editing a paragraph). That is to say, these tools enable us to achieve new cognitive transformations that would be either impossible or very challenging if we depended only on our neural capabilities (Overmann, 2021).

Taking this argument further, Menary and Gillet (2022) argued that human cognition is profoundly enculturated and that our ways of learning have changed our brain. Furthermore, according to their argument, “[e]nculturation gives us the resources to explain how we come to be a cognitive tool-using species and how humans acquire the capacities for deploying cognitive tools when completing cognitive tasks” (Menary & Gillett, 2023, p. 4). These tools, they continue, (1) cannot be separated from their cognitive practices; (2) transform the cognitive abilities; and (3) lead to neurocognitive changes.

Cognitive tools (such as physical objects, representational systems, and cognitive practices) integrate into our cognitive systems and transform them in ways that lead us to think and act in new, enculturated ways (Menary & Gillett, 2022). Enculturation leads to the formation of cognitive systems that integrate tools and cultural practices as constitutive components rather than as developmental aids or causal supports (Menary & Gillett, 2022). There are three categories of cognitive tools: (1) symbolic tools (writing systems, computer languages, frames of reference); (2) sensory tools (tools to extend our senses, such as microscopes, telescopes, compasses); and (3) tracking tools (rulers, protractors, GPS). As social individuals, humans have access and regularly extend and alter cognitive capacities though cultural learning. These modifications are the cognitive tools that we use, and which could not have been invented in a lifetime. Enculturation, therefore, goes beyond task structuring and temporary scaffolding, as these tools become integrated into our cognitive system, rather than temporary structures that facilitate learning (A. Saarinen, 2020; Sutton, 2016).

Cognitive tools are, therefore, a core part of how we think and reason in the world. Learning how to manipulate them transforms both the task and our neurocognitive profile. Moreover, the use of a cognitive tool to accomplish a task involves not only the interaction between the individual and the tool but also the acquisition and mastery of a set of cognitive practices. These practices, in turn, guide the physical manipulation of those tools (Menary & Gillett, 2022). That is to say, cognitive tools can enculturate of the body, as illustrated by Abrahansom and Sánchez-García (2016) argument that learning is moving in new ways.

In that sense, it can be argued, these ideas link with the general framework of the Extended Evolutionary Synthesis (EES) in that they incorporate additional mechanisms and concepts to emphasise developmental plasticity in shaping evolutionary outcomes (Müller, 2017; Pigliucci & Müller, 2010). The EES is a theoretical framework that proposes an expansion of the traditional understanding of evolutionary processes. According to this theory (Laland et al., 2014; Laland et al., 2015) genetic factors alone do not fully account for the diversity and complexity of biological systems. Amongst others, this theory highlights the role of niche construction, where organisms actively modify their environments, influencing selection pressures and contributing to evolutionary change. It can be argued, therefore, that humans are biologically equipped to acquire culture and adapt to sociocultural environments throughout their lives (Wexler, 2008), cooperatively constructing the niches they inhabit. In doing so, the new cultural affordances are presented and become new ways of perceiving and acting shaped by cultural norms and practices (Ramstead et al., 2016). These novel environments influence our cognitive capacities, sense of self, skills, and meaning-making, rewiring brain plasticity in ways that only make sense in relation to the particular sociocultural and historical context from which they emerged (Kirmayer et al., 2020).

2.6.1.5. Ontophanic Resonance

Moreover, Raja (2018, 2019, 2021), highlighting the role of those cognitive environments in the shaping of intra-organismic dynamics, argued that ecological psychology needs to explain the role of the central nervous system in perception, action, and cognition while staying true to its tenets. That is to say, a "central metaphor according to which the animal perceives its environment by ‘resonating’ to information in energy patterns” (Raja, 2018, p. 29). He articulated a theory according to which, rather than computing outer stimuli, the Central Nervous System (CNS) resonates with outer information (Raja, 2021). By doing so, he outlined an account of cognitive architecture that is non-computational, therefore remaining aligned to ecological psychology and its principle of direct perception (Gibson, 1966; Gibson, 1979/2014); that is to say, without need for computational or representational mechanisms.

Whilst computational approaches understand the interaction between agent and the environment as one of internalisation of external stimuli, for ecological psychology, that relationship is always ecological. That is to say, the interaction is not one of computation but one of resonance to the ecological information. The term resonance was first proposed by Gibson (1966) and although it has been addressed by others (Chemero, 2013; Michaels & Carello, 1981; Reed & Bril, 1996; Turvey et al., 1981) it was not until Raja’s (2018) Theory of Resonance that the concept was fully developed beyond a mere metaphor. Raja (2018) described resonance as a model that explains the coupling (correlation) between the dynamic systems behaviours at the organistic and ecological scales. Challenging the representational notion of “poverty of stimulus” (Chomsky, 1980) ecological psychology argues that ecological information is specific, unambiguous, and sufficient (Raja, 2018, p. 35): the agent, rather than having to construct information out of sensory outputs, is tasked with finding the relevant information in a sea of ecological complexity.

From an ecological psychology point of view, there is only a causal chain that can be explained by the application of physical laws at an ecological scale (without the need for internal representational mechanisms). Raja’s (2018) theory of resonance relies on the parallels between Anderson’s (2014) theory of neural reuse and ecological psychology, in that both can be explained in terms of Dynamic System Theory (DST) (Thelen, 1992), where the former captures the intra-organismic dynamics whilst the latter does the same at an ecological scale: “a complete explanation of resonance also requires showing the specific kind of relation between the two dynamic systems. In other words, a model to explain resonance must explain how the dynamic systems at the two scales are coupled” (Raja, 2018, p. 40). That is to say, that the main variable of the dynamic system model at the ecological level is also the main variable at the intra-organismic scale. According to this argument, therefore, an ecological variable that constrains the interaction between the agent and the environment also constrains the intra-organismic system when the dynamics at organism level are modulated by the influence of ecological level (Raja, 2018). Methodologically, resonance theory relies on the application of a multilevel-fractal analysis that addresses structural properties (and patterns) found at different scales. Raja (2018) coined the expression *multi-scale fractal DST* (p. 46) to indicate that the intra-organismic and ecological system is not only coupled but represents two different scales of the same phenomenon.

Furthermore, Raja (2018) argued, intentional systems exhibit self-organised criticality (the systems organised themselves in a way that allows them to rapidly change from a pattern to another). In order for this to happen, the dynamics of a larger scale must constrain that of a smaller (as in the case of ecosystem-intra-organismic). A resonance perception of the relation between the organism and the environment implies accepting that ecological constraints have an impact on intra-organismic patterns and therefore on the emergence of particular cognitive dynamics. In other words, the integration of neural and behavioural scales of analysis (Raja, 2021) brings renewed attention to the nested dimension of perception-action loops, particularly when these environments are digitally constituted.

Moreover, Artefactualism (Sanches de Oliveira, 2022) referrers to the construction of models (mainly scientific) as tools. However, in the context of this study, artefactuality refers to the process of creating artefacts; that is, objects that emerge out of human manipulation. Although artefacts inherit traits from material engagement (as discussed in the previous section), due to their cultural aspect, they also participate in what Tomlinson (2017) referred to as epicycles. That is to say, artefacts are fed back by the organism into the environment and, as new constituents of the environment, impact both on the organism and the environment once again in a constant interpenetrated process of becoming. In the process of manipulating those artefacts, the topography of those artefacts touches the subject and defines the landscape or architecture of ideation (Petitmengin, 2021).

Material engagement, therefore, can be seen as a constitutive aspect of cognitive processes and agency. However, although it has been extensively studied in relation to material environments —particularly around skill development and social and distributed cognition— there is a need for critical enquiry into material engagement and enculturation in the context of the digital. It is worth noting, however, that it is not my intention to introduce a dichotomy between material and digital; or to suggest that the digital does not have materiality. However, as it will be explored in Chapter 6: The digital as a new structure of ~~perception~~ learning, the results of this study seem to indicate that they operate under a distinctive set of rules and, therefore, some form of differentiation could be granted.

2.7. The Methodological Framework

Ceder (2020) proposed that education theory should be positioned in what he calls educational relationality. That is to say, research in this area should not look inwards into the subject nor outwards towards the objects but be concerned with the dynamic relationships between both human and non-human elements in a constantly shifting scenario of mutual becoming. He argued that the field of education has a history of separating subjects from things. Lenz-Taguchi (2009) calls this inwards-looking history intra-personal and linked it to traditional theories of cognition occurring inside the learner. Similarly, the influence of socio-constructivism has advocated for an inter-personal approach focused on the interactions with the environment and the social (Pischetola & Dirckinck-Holmfeld, 2020). Educational relationality (Ceder, 2020), however, by highlighting the relevance of the actual web of relationships rather that the who or what with, is a reaction to both intra- and inter-personal approaches.

Intra-active pedagogy (Taguchi, 2009), the basis of educational relationality, shifts the attention from intra-personal and inter-personal relationships toward interdependent and intertwined relationships between people, living things, and the material environment of objects, artefacts, and spaces. Highlighting the importance of the material as performative agents (Barad, 2007), Lenz-Taguchi (2009) challenged binarism such as theory/practice and discourse/matter, arguing for a performative agency based on the importance of connections and interrelationships instead of separation. Learning (and knowing), therefore, becomes something that occurs in the interconnections that take place in-between different forms of matter making themselves intelligible to each other (Lenz-Taguchi, 2009), thus conceptualising the material as an agent that is active both in the construction of discourses and reality. This new material turn pays particular attention to material culture, material agency, but also artefactuality.

Therefore, considering Ceder's (2020) recommendation to approach education as a relationality (that is to say, where relata emerges from the intra-penetration of properties in phenomena), the present research looks "to decenter the human position and continue to study when students engage in relations with technology" (Ceder, 2020, p. 140). To that point, two methodological approaches were selected as a way to intersect (1) the description of the experience from the first-person perspective (micro phenomenology); and (2) the localised socio-material perspective (micro ethnography), described further in the sections below. This research, thus, is positioned in the field of educational relationality. That means it seeks to understand the learner not as an educational subject but as rethought in an entanglement that includes embodiment and materiality "in a constant re-shaping and becoming in the world" (Ceder, 2020, p. 102). As such, the current study moves away from an educational perspective of the subject learner relating to the world, towards an educational relationality where "the learner and the world cannot be separated" (Lenz-Taguchi, 2009, p. 47). Educational relationality, then "is not about creating entanglement – it is about observing the entanglement that is already there" (Ceder, 2020, p. 144).

In the next sections, the methodologies used are discussed in detail, starting from the umbrella disciplines (Phenomenology and Ethnography) and continuing on the specificities of the 'micro' disciplines.

2.7.1. Phenomenology and Ethnography

As presented in the preceding sections, educational relationality is a complex phenomenon that is concerned with an integration of the subject with the world. Two particular methodologies come to mind when considering the study of phenomena (phenomenology) and the study of social practices around artefacts (ethnography). The methodologies selected for the current study, micro phenomenology and micro ethnography, stand each as their own methodologies. However, and in order to present a full picture, I briefly introduce the parent disciplines of phenomenology and ethnography. These descriptions are not intended to be comprehensive by any means but are meant to offer the reader a general context of the historicity and the main methodological directions of both. More details about these approaches are provided both in Chapter 3: Methodology and Chapter 4: Intervention.

2.7.1.1. Phenomenology.

Phenomenology is a philosophical movement that emerged in the early 20th century and was primarily championed by Husserl (1970). Its roots, however, can be traced back to earlier philosophical traditions. The term "phenomenology" itself was first used by Lambert (1764) to distinguish truth from illusion and error, and further developed by Hegel (1807/2012) as he explored the development of human consciousness (Biemel & Spiegelberg, 2024; Spiegelberg, 1975). Husserl's phenomenology began in the early 1900s with the publication of *Logical Investigations* (2000), in which he sought to establish a rigorous scientific foundation for philosophy by focusing on the direct investigation and description of phenomena as they are consciously experienced.

Phenomenology, therefore, comprises the study and theory of lived experience (Brinkmann & Friesen, 2018) as one that does not sit in isolation but in a schema of earlier memories, expectations, and previous experiences (Gadamer, 2013). There are a variety of approaches to phenomenology, and although all of them focus on the personal experience of living, their understanding of the purpose of the methodology varies. Thus, Husserl (1970), interested in a return to the things themselves, grounded his phenomenological approach in transcendental consciousness, intending to obtain a scientific understanding of it. Heidegger's (1927/1996) posthuman perspective, on the other hand, considered hermeneutic phenomenology as an existential process of understanding the self and the act of being. For him, consciousness was entangled with being, and the conditions of this entanglement vary from subject to subject. Finally, Merleau-Ponty (1962, 1975) took on the embodied experience, developing a theory that contradicts Husserl's egology by focusing instead on "the unity of the flesh of body and world" (Brinkmann & Friesen, 2018, p. 3).

According to Brinkmann and Friesen (2018), the intersection of phenomenology and education has a rich and extensive history. Phenomenology, with its focus on the experiential, relational, and intersubjective dimensions of human existence, has significantly influenced educational theory and practice. Whilst in Germany phenomenology has been instrumental in redefining traditional theories of *Bildung* (personal formation) and education by integrating both empirical and theoretical perspectives, in the English-speaking world, phenomenology has primarily served as a methodological approach to illuminate lived experiences and occasionally provided new ways to articulate theories of teaching and learning that are closely connected to concrete educational practices, as exemplified by the early work of Fischer (1968) and the Munich school, all the way to the work of Max van Manen (2014), and Moustakas (1994). Following on this long tradition of phenomenological studies in education, this research is informed by the work of Claire Petitmengin (2006, 2017, 2021) and her micro phenomenological approach (described in Section 2.7.2.1: Micro Phenomenology).

2.7.1.2. Ethnography.

Ethnography is a form of qualitative research that involves researchers immersing themselves in a particular community or organisation to observe particular behaviour and interactions. As such, it is a reflexive process (Hammersley & Atkinson, 2019) that looks to understand how people make sense of their everyday world (Harrison, 2018). The word "ethnography" also refers to the written report of the research that the ethnographer produces afterwards (Abu-Lughod, 2000). Ethnographic research, therefore, "seeks to create as vivid and analytical a reconstruction as possible of the culture of groups being studied" (Cohen et al., 2018, p. 292). This approach is a study of the values, beliefs and practices of a group, society, or community. However, it can also be used to study a specific people or small groups (Cohen et al., 2018).

Within the context of the current study, using ethnography as a methodological approach would involve observing learners in a natural environment, in order to understand the contextual culture of the people being observed by relying on a grounded, reflexive analysis of what people do, say, and not do and say. Ethnographic microanalysis is also known as micro ethnography, and it "stands as a discourse-and-interaction analytic research method that can in fact support the empirical characterisation of what people do when they interact face to face in everyday life" (Garcez, 2017, p. 445). It is the intention of this research to explore if that approach in combination with the ANT principle of general symmetry can be apply to human-non-human interactions.

2.7.2. The 'Micros': Micro Phenomenology and Micro Ethnography

Rooted in the rich traditions of phenomenology and ethnography, the terms micro phenomenology and micro ethnography do not emerge as mini versions of the parent disciplines. Instead, these methodologies possess their own particular foci: micro phenomenology is designed to describe the singular experience via a robust analytical description from the perspective of embodied dynamics, whereas micro ethnography focuses on the study of micro cultures (such as that of a classroom) or the iterative study of a singular, short event across a number of individuals. That is to say, the focus of micro phenomenology "enables the scientist to collect descriptions of singular lived experiences" (Petitmengin, 2017, p. 140), while micro ethnography is concerned with creating a description of the "local and situated ecology among participants in face-to-face interactional engagements constituting societal and historical experiences" (Garcez, 2017, p. 436). The next sections present the particularities of each one of them in the context of this study as a continuation of the arguments presented in the four main threads (Philosophical; Technological; Cognitive; and Material Engagement).

2.7.2.1. Micro Phenomenology: The First-Person Voice.

Petitmengin (2017), following Nisbet and Wilson's (1977) research on the limitations of introspective access to cognitive processes, argued that accessing that experience can be more difficult than expected, since we have a very limited understanding of our lived experience and the very process from which arises. From her perspective, experience is not at all what we might think it is, since a representation of the experience is superimposed on the experience itself, as the content of the experience (the “what”) creates a narrow attention tunnel that conceals the activity itself (Petitmengin, 2021). Often, the ”what” is represented discursively, thus ignoring the “how” and creating a disembodied experience. It is important, therefore, to explore these spaces of ideation in order to discover the invisible micro-genesis of thought, emotion, and choice, because “in the early stages of the microgenetic process, it seems that the qualitative difference that we usually perceive between abstract thought and bodily sensations reduces. Experience is initially ‘felt’” (Petitmengin, 2017, p. 144). In these transmodal felt spaces, the boundary between the sensory modalities becomes more permeable; softening the perceived separation between body and mind, and between inner space and outer space, in a kind of naturally occurring synaesthesia that resembles the way in which infants first perceive the world around them (Stern & Lazartigues, 1989) and which forms an active stratum on which thought is anchored. Moreover, Petitmengin (2021) argued that it “is from this sensitive and fluid matter where the distinction between mind and body dissolves that our ideas seem to be made” (p. 174), as the landscape (or the topography) touches the subject. In other words, the experience and its context are not independent.

Following this idea, micro phenomenology argues that as soon as the phenomenon is recognised, the “I” comes into existence. They emerge simultaneously. “We do not have two separate poles, subject and object, but one spectrum of increasing solidity or density of the experience of the subject-object couple” (Petitmengin, 2017, p. 146) by which they are co-constituted (Varela et al., 1991/2017). Micro phenomenology (MP) will be addressed in more detail in Chapter 3: Methodology. However, as a brief introduction, it is possible to describe MP as a recent methodology. MP was developed based on Varela’s (1996) neurophenomenological approach and Vermersch (1991) *l’entretien d’explicitation.* MP enables the researcher to reliably access dimensions of the lived experience of the participants and describe them accurately and reliably through a systematic and robust process of analysis. The intention of adopting this approach for the present study is to “turn the direction of the movement of thinking from its habitual content-oriented direction backwards toward the arising of thoughts themselves” (Varela, 1996, p. 337). The purpose of doing so is to discover the microgenesis, maturation, and emergence of ideas (Petitmengin, 2017) and choices (Petitmengin et al., 2013) with a particular focus on the re-connection of the thinking processes to the experiencing body (Schoeller, 2021).

Human Computer Interaction (HCI) “is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them” (Sinha et al., 2010, p. 1). As such, the study of the experience of learning with digital technologies is also part of its scope. HCI has traditionally been focussed on usability. However, the third wave of HCI has brought a new focus on the experiential and the affective design, trying to understand in depth the user’s experience (Duarte & Baranauskas, 2016; Harrison et al., 2007). Micro phenomenology is helping develop a vocabulary to describe multi-sensory experiences in order to unfold embodied tacit knowledge (Prpa et al., 2020), by providing “an open link to empirically based description (...) where neither experience nor external mechanism have the final word” (Shear & Varela, 1999, p. 2). Petitmengin (2006) argued that “in order to study cognition one can no longer limit oneself to data that can be observed and recorded from the outside” (p. 229), since the description of the cognitive processes is in the first person. Consequently, she developed micro phenomenology as a method that enables the gathering of first-person data through the interaction with another person, and therefore becomes a second person method (Varela & Shear, 1999).

There are three approaches in HCI to interpreting user experience: the measuring approach, the empathic approach, and the pragmatist approach (Harrison et al., 2007; Prpa, 2021). Whilst the first two claim that experience is emotional in nature, the pragmatist approach “shows that experiences are momentary constructions that grow from the interaction between people and their environment. (...) [E]xperience fluctuates between the states of cognition, subconsciousness and storytelling, depending on our actions and encounters in the world” (Battarbee & Koskinen, 2005, p. 7). In other words, aligning with the micro phenomenological approach, the pragmatist approach considers users’ encounters as embodied, felt experiences that unfold. However, quite often, we confuse an experience of our cognitive activity with a representation of it, our belief of what it is (i.e., riding a bicycle, contemplating nature, breathing). These representations, mainly conveyed by language, are learned and correspond to specific cultural contexts (Petitmengin, 2006). As a result, these representations (a) have a deforming effect on the description of the experience and, (b) they can conceal experiences that do not match our representations, because our preconceptions of what the experience is -or should be- take over from the act of sensing the experience.

Micro phenomenology offers a robust method to capture the complexities of these unfolding experiences, and a number of HCI researchers have turned to it as a way to support users in the recollection of their lived and felt experience (Prpa et al., 2021). In the same way that this approach is aiding design research, it could also help elucidate the micro genesis of thoughts by looking into the cycles of self-stimulating activity (Clark, 2011) and their interrelation to mental and bodily schemas. As indicated in Section 2.6. The Material Engagement Thread, there is a long tradition of studying skill-acquisition in particular contexts, but –to the best of my knowledge– although there are a few studies focused on material engagement with the digital, there are still a lack of granular description of the processes of phases of that engagement. Therefore, such an approach could be of use to better describe the microgenesis of thoughts when learners interact with a digital device in the classroom; or, in the language of this study, when the landscape "touches" the subject.

2.7.2.2. Micro Ethnography: People and Artefacts.

Although classical anthropological ethnography is typically characterised by long-time researcher immersion amongst a relatively cohesive, "foreign" group, as ideologies fluctuate, academics from around the world have been creating new ethnographies (Wall, 2015). Focused ethnography is one such adaptation, and it is characterised by attention to a distinct problem within a sub-cultural group. Other research formats that resemble focused ethnography can be referred to as mini ethnography; micro ethnography; rapid ethnography; and even quick-and-dirty ethnography (Millen, 2000; Muecke, 1994). They are also referred to as technographies (Kien, 2008) because of its focus on producing deliverables within a tight schedule. Micro ethnography was introduced by Erickson and Mohatt (1982) as a research tool for the microscopic analysis of naturally occurring human activities and interactions (Alvarez-Hevia, 2014). In micro ethnography (ME), the traditional perception that long-time engagement equates 'thickness' is replaced by a "shorter fieldwork informed by continuous dialogue with theory and multimodal means remembering to take into consideration more resources than discursive ones" (Alvehus & Crevani, 2022, p. 238). Streeck and Mehus (2004) pointed out that, initially, ME was influenced by ethnomethodology (an enterprise brought about by a departure from traditional sociological conceptions and a growing focus on microlevel processes in the hope that they could offer an explanation for macro level phenomena). Another influence that they point out was that of structuralist-linguistic conceptions (such as Pike, 1967). However, as the discipline evolved over time, an increasing detachment from linguistics and a stronger focus on action can be observed (Pike, 1967).

Micro-ethnography "focuses on aspects of bodily communication, such as gaze, gesture, postural configurations, and interactions with artifacts" (Asare, 2015, p. 213), addressing the big moments via a careful analysis of the small moments of life (LeBaron, 2008). As Albury (2014) argued, “a new direction for ethnography is possible, one that connects it more closely to design and to the role of e-science in providing education researchers with a richer starting point for [critique] of technology-based interventions” (p. 10), due to its “in-depth description of complex environments from which patterns of behaviour can be mapped onto principles for the design of artefacts” (Albury, 2014, p. 10). The term “micro ethnography” refers to the microscopic analysis of human interaction and activities that occur naturally (Streeck & Mehus, 2004). It was originally suggested by educational researchers to characterise their particular strategy to analyse complex urban classrooms (Smith & Geoffrey, 1968). However, the term itself was not coined until the beginning of the 1970s, when Erikson (1971) introduced it to a group of researchers who, thanks to having access to more suitable recording material, had started the study of moment-by-moment interactions of the classroom. “Micro” can refer to the shorter amount of time of field work (Alvehus & Crevani, 2022) compared to that of more traditional ethnographic approaches; or –as argued by Streeck and Mehus (2004, p. 381)– to the size of the “cultures” that they describe, since they tend to focus on classrooms or schools rather than entire societies.

Apart from these differences, the methods adopted are not different from those of traditional ethnography, including interviewing and participant observation, with an emphasis on conversation analysis and sequential organisation of interaction events. Some of the disciplines associated with the new school of micro ethnography (Steeck & Mehus, 2004) include: cognition as practice, communities of practice, distributed cognition, and cognitive ethnography. Although different in certain aspects, what unifies their work is the recognition that “cognitive processes do not take place exclusively—not even in the first place—inside people’s heads, but in the outside world” (Streeck & Mehus, 2004, p. 387). A recognition that, as well as communicating using our voices and bodies, we also do so with material objects (Steeck & Mehus, 2004, p. 389).

Alvehus and Crevani (2022) argued that “[t]o account for the participation of human and non-human actors, recording voices in interactions is not enough” (p. 240). They pointed out a number of alternative ways to attend the multimodality of these interactions. For instance, using photos for capturing how space is configured (Case & Śliwa, 2020); capturing atmospheres and rhythms, by combining notes that reflect how the researcher is experiencing a situation with pictures of the situation and of specific artefacts (Crevani, 2019; Katila et al., 2020). Van De Mieroop’s (2020) study brings non-verbal interactions (such as head shakes, gazes, eyelids closing, uses of stationery, etc.) to the forefront as a way to offer detailed descriptions of how things are done. This flexibility affords micro ethnography an extremely detailed account of practice (Alvehus & Crevani, 2022, p. 240). At the same time, video recording allows for a detailed analysis, like in the case of micro-genetic analysis (Siegler & Crowley, 1991), this moment-by-moment analysis what makes micro ethnography "different and unique" (Bayeck, 2023, p. 2). Micro ethnography in education enables work at the micro-level of the school or classroom. This allows for a limited setting analysis rather than considering an entire culture as traditional ethnographers do (Alvarez-Hevia, 2014). This methodology affords detailed observations "that focus attention on the intricacies of everyday behaviour in the classroom [. . .] that aims to provide the researcher with experiences, anecdotes and stories that are processed and reconstructed into narratives" (Alvarez-Hevia, 2014, p. 4).

Narrative analysis, a subset of ethnography, is an umbrella term that covers a number of methods (Esin, 2011) and is characterised by a recollection of stories gathered from the participants' accounts. There is a plurality of approaches, depending on what feature of the stories the researchers decide to focus on. Esin (2011) identified three types of modes to narrative analysis: structural model (Labov, 1972); thematic model (Riessman, 2008); and interactional/performative model (Denzin, 2001; Mishler, 1995; Riessman, 1993). The structural model is focussed on the structure of the stories and the way in which they are told. The thematic model focuses on the content of those stories and the themes around them. Finally, the interactional/performative model looks at the contextual features that shape the narratives and how meaning is collaboratively constructed in the interactions between narrator and listeners. Similarly to the micro phenomenological interview, narrative interviewing uses open, non-leading questions, prioritising the elicitation of stories with minimum intervention from the interviewer (Esin, 2011).

Another model that can be used to conduct a narrative analysis is the thematic model (Riessman, 2008). The present study employs this model. The thematic model focuses on the content of the narrative, looking at identifying a set of themes by looking for patterns and meaning. An important distinction needs to be made here between two terms: story and narrative. People tell stories, not narratives (Smith, 2016, p. 204). These stories are the ones that "imbue our experience with 'meaning'" (Mayer, 2014, p. 7). Narratives, on the other hand, can be depicted as the scaffolding upon which people build their stories using a menu of narrative resources made available to people via cultural and interpersonal relations (Smith, 2016). Those narratives are not just instruments to tell personal stories or motivate our actions (Mayer, 2014), but actual actors (Frank, 2010). They are not passive, but are our primary medium for action (Smith, 2016). Moreover, narratives are crucial pathways to understanding and constructing oneself and one's identity (Noy, 2004). They are embodied and they are performed with and for people in interactional, socio-material contexts, in which they become (1) mediums-for-doing: that (2) use the body as communicative, structuring, and interpreting parts (Smith, 2016).

Ethnographic research (and therefore ME too) “often grows from an observation that a material element accomplishes something important” (MacLeod et al., 2019, p. 177), as is the case of digital devices in this research. ME documentation can take the form of “1) document and artefact analysis; 2) observation; and, 3) interviews”. Moreover, ethnography, understood as “the systematic study of people and cultures from the perspective of the subject” (Hobbs, 2006, p. 102), offers a fertile landscape for the study of these dynamics in education (Fenwick, 2015; Fenwick, 2011). The same can be said about micro ethnography (Garcez, 2017; Roe, 1994), since narratives offer a way to understand people’s interactions, beliefs, and contexts (Saint Arnault & Sinko, 2021). There is evidence of a growing view of narratives as powerful forms of giving meaning to experience (Braun & Clarke, 2022; Esin, 2011). This, in turn, supports an increasing consensus not only of the importance and usefulness of narrative analysis as an element of doing ethnography (Coffey et al., 2004; Cortazzi, 2001; Gubrium & Holstein, 2008); but also of ME as an effective framework for narrative analysis (Bloome et al., 2004; Kabatanya & Vagli, 2021; Kim, 2012; McConnell, 2018).

2.8. The Gap

Fuller and Jandric (2019) suggested that in some versions of the postdigital, the digital appears as “the master narrative of our world” (p. 215), and one would expect, therefore, that educational research should be engaging head-on with digital technologies beyond mere tools in order to address its complex role in an authentic postdigital society. However, Knox (2019) argued that there has been a “general lack of rigorous engagement with the very idea of technology in educational research” (p. 360), since the current project of education “is overwhelmingly viewed as a matter of human development, [. . .] in which technology only features in a supporting role, typically as an uncritical ‘enhancement’ for learning” (Knox, 2019, p. 361).

Supporting this idea, Pischetola and Holmfeld (2020) pointed out that the constructivist model of education that had dominated the last thirty years falls into an instrumentalist, Cartesian approach, as “ICT and online learning platforms are seen as a dissociated element of pedagogical practice or the learning process, another tool that ‘supports’ teaching practice” (p. 2). In their opinion, “[e]nactivism proposes a more radical alternative to the Cartesian dualistic and objective approach, as it focuses on the intertwined and multiple interactions between mind, body and the environment” (Pischetola & Holmfeld, 2020, p. 2). This view is mirrored by authors supporting the emerging field of embodied cognition, who see cognition as deeply interwoven with the subject’s physical interactions with the environment.

Furthermore, Shapiro (2019) insisted that “traditional cognitivist accounts of the mind should be challenged because they exclude the close relationship that exists between mind and body” (p. 20). Farina (2021) also agrees with this point, suggesting that studying cognition from a fully embodied perspective could be able to offer an explanation of sophisticated cognitive capabilities, including higher-order-thinking. From a similar perspective, but more concerned with material practice, Hutchins (2010a) mentioned that in the study of cognitive phenomena, some elements of cognitive ecology have been present but have never been at its core. He adds that “[o]ne of the biggest challenges of the coming decades will be working out the implications of the fact that for humans, the ‘world’ (in the now familiar ‘brain–body–world’ formulation) consists of culturally constructed social and material settings” (2010, p. 711). These arguments point out towards the need for educational research positioned at the intersection of embodiment and socio-material studies.

However, this study is not only concerned with engaging with digital technologies at a deeper level; as suggested by the paragraphs above, but it also intends to address the “scarcity of foundational knowledge about how learners themselves perceive, engage, and adopt deep learning practices” (Fullan & Langworthy, 2013, p. 15). As Bennet and Bennet (2008) clearly stated, “there is a crying need in organisations to learn more about deep knowledge. We call this body of ideas action theory because of the direct link between knowledge and action” (p. 1).

Most of the literature seems to address the effective use of devices in class (Daud, 2020). However, there is still a lack of granular understanding on the phases or processes that take place when students use digital devices for learning (Lai, 2018). Despite of the ubiquitous presence of technology in everyday life and the classroom; and regardless of the fact that “materials – objects, bodies, technologies, and settings – permit some actions, and prevent others” (Fenwick, Doyle, et al., 2015, p. 122), digital technologies are not thought as objects but “as portals through which we experience millions of bytes of data” (Mulready, 2023, p. 146). In this study, I intend to investigate and demonstrate that (1) the digital is a form of materiality that, rather than acting as a portal through which we experience things; (2) it becomes the structure of our experience and action. I hope that this centrality, in turn, will dispel perceptions that position digital technologies as peripheral to education, bringing it back into educational discourse not in an instrumental capacity, but as an integral component of the learners' cognitive processes. The study therefore suggests that this entanglement is one of the constitutive elements of the Aesthetic School. This change in positionality from intra or inter subjective (Lenz-Tagochi, 2009) to relationality (Ceder, 2020) will allow educational reform (Sahlberg, 2023) to finally realise the promised transformation of education (Ganimian et al., 2020) by rewriting the grammar of schooling (Tyack & Tobin, 1994).

Moreover, as Daoud (2020) pointed out in her systematic review of the literature of ICT in the classroom, most of the studies tend to examine the effectiveness of a particular intervention rather than the device-student relationship. She insisted that "there is a need for in-depth investigations of using devices by students that consider the open nature of the classroom contexts, what factors shape them, and how they could contribute to classroom learning objectives" (Daoud, 2020, p. 48). However, as also pointed out by Bennett (2019), there is a gap in the research on technology in education from the student's point of view, particularly with regard to the classroom and focussed on the actual use by the learners. This research, therefore, adopts a methodological approach that would allow the study to address the gaps mentioned. (1) Micro phenomenology allows for an analytical perspective based on the first-person, giving voice to the student's point of view. (2) Micro ethnography considers not only the socio-cultural practices in context (also from the perspective of the first-person) but also allows for enquiries into the material relationships between cultural practices, values systems, and material engagements in the context of the classroom.

2.9. Literature Synthesis and Theoretical Framework overview

In this literature review, I have first defined Entanglement as a complex system of engagements, hybridities, and interdependencies amongst the human and nonhuman components of phenomena that create a flow of agencies. Then, I have presented a review of the current literature in what I argue are the fundamental paradigm-shifts that arise from the dynamic of the Two Schools. The literature review is organised into four threads (Philosophical, Technological, Cognitive Shift, and Material Engagement) that collectively challenge traditional educational paradigms and support a shift towards understanding digital entanglement between students and devices.

The four threads explored in this literature review (synthesised in Figure 1 below) converge to articulate a fundamental paradigm shift in educational understanding, moving from what I term the Anaesthetic School towards an emerging Aesthetic School of educational practice. Figure 1 presents a synthesis of the main ideas covered in this literature review.

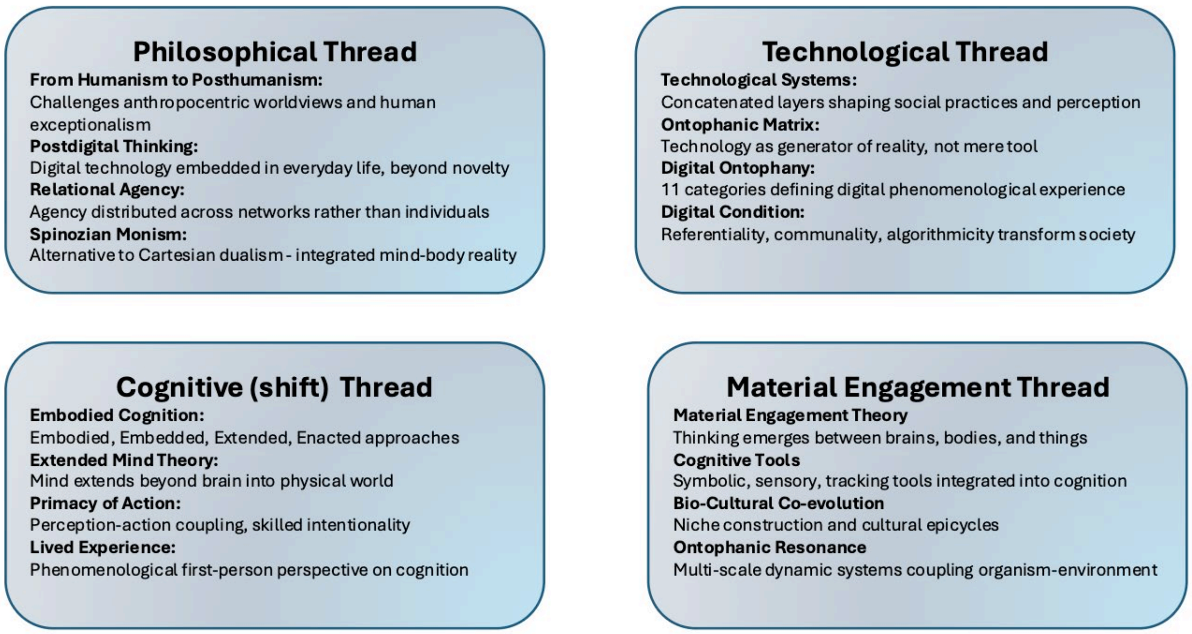


Figure 1

Literature Review synthesis

The Philosophical Thread explores a transition from humanist, anthropocentric worldviews towards posthuman and postdigital perspectives that decentralise human agency and recognise the distributed nature of cognition across human-nonhuman assemblages. Similarly the Technological Thread presents, first, how technology is constitutive of human activity, and how digital technologies function not merely as tools but as ontophanic matrices, generators of reality that fundamentally reshape our perceptual experiences and ways of being in the world. This digital embeddedness creates what Stalder (2018) identified as the digital condition, characterised by new forms of referentiality, communality, and algorithmicity that transform social practices.

The Cognitive (Shift) Thread challenges the brain-bound, representational model of cognition that has dominated educational discourse, proposing instead an embodied, embedded, extended, and enacted understanding of mind. This shift emphasises the primacy of action, the coupling of perception and movement, and the recognition that cognition emerges through dynamic engagement with both material and social environments. The Material Engagement Thread synthesises these insights by presenting how thinking emerges not within isolated minds but between brains, bodies and things (Malafouris, 2013). This thread reveals how cognitive tools become constitutively integrated into our thinking processes through bio-cultural co-evolution, creating hybrid assemblages where agency is distributed across human-nonhuman networks.

This synthesis of the main ideas of the four theoretical threads provides the foundation for constructing a unified theoretical framework that addresses the central research questions of this study. Figure 2 presents a simplified visualisation of the research framework adopted by this study.

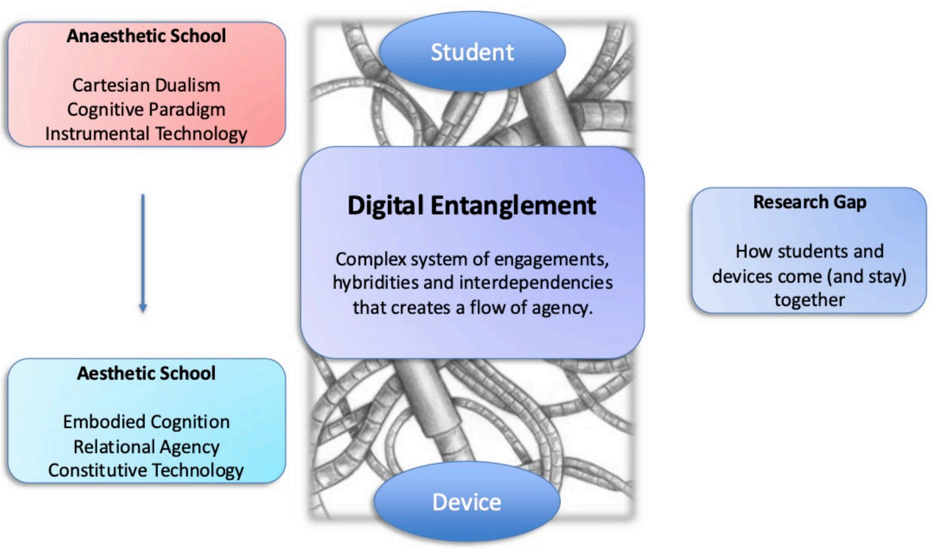


Figure 2

Digital Entanglement research framework

Together, the theoretical thread presented in this chapter's threads support idea of a shift towards the emergence of what I conceptualise as the Aesthetic School, an educational material-discursive configuration characterised by digital entanglement and educational relationality (Ceder, 2020). This conceptualisation of school recognises that learners and digital devices exist in states of constitutive interdependence, where boundaries between self and technology become fluid and agency emerges through relational intra-action rather than being an individual possession. Figure 3 captures these fundamental shifts as well as the characterisation of the Aesthetic School.

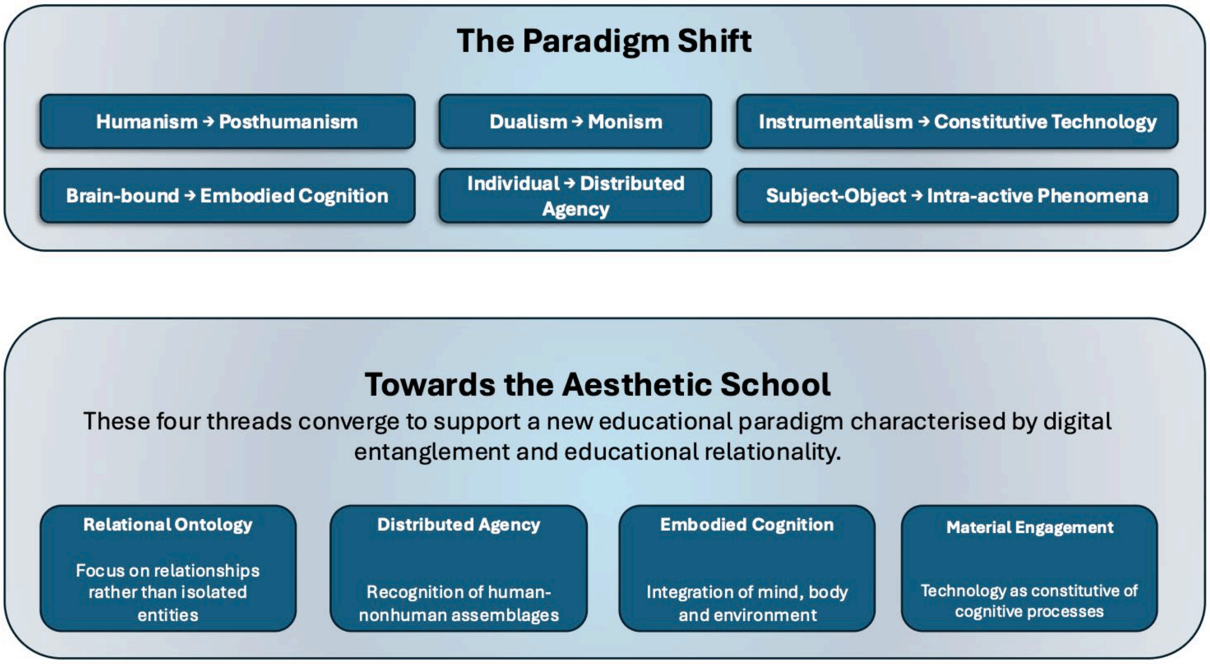


Figure 3

Paradigm shifts towards the Aesthetic School

The present study's theoretical framework centres on the concept of Digital Entanglement, defined as a complex system of engagements, hybridities and interdependencies amongst human and nonhuman components that create a turbulent river of interactions where agency emerges as a dynamic flow. This definition, drawing from Barad's (2007) notion of quantum entanglement, represents a fundamental departure from conventional understandings of human-technology relationships in educational contexts. Rather than viewing students and digital devices as separate entities that interact externally, Digital Entanglement conceptualises them as components of a unified phenomenon whose properties emerge from their relational coupling.

The framework moves beyond digital integration to propose a fundamental paradigmatic shift that reconceptualises the nature of learning, technology and human-nonhuman relationships in educational settings. Figure 4 offers a visual representation that illustrates the conceptual apparatus for investigating digital entanglement in educational contexts adopted by this study.

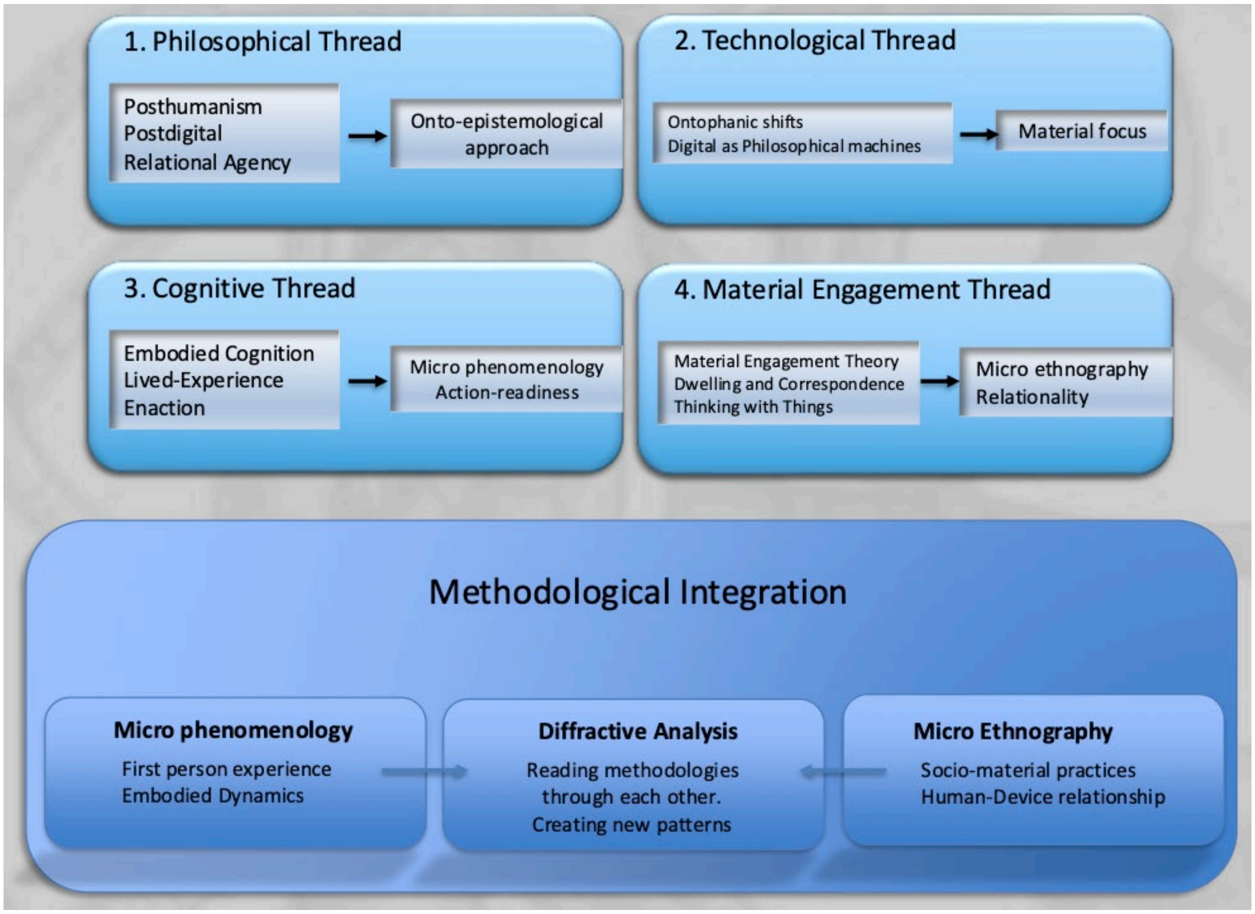


Figure 4

Digital Entanglement theoretical framework and methodological integration

The methodological integration of micro phenomenology and micro ethnography through diffractive reading represents the practical operationalisation of this paradigmatic shift. Each theoretical thread directly informs specific methodological decisions: the philosophical thread underpins the onto-epistemological approach that integrates being, doing, and knowing; the technological thread illustrates why digital affordances and ontophanic conditions require a material focus; the cognitive thread presents how attention to lived experience and embodied and enacted approaches support a micro phenomenological methodology that prioritises first-person experiences; and finally, the material engagement thread proposes how the investigation of socio-material practices necessitates micro ethnographic approaches.

Through diffractive analysis, these methodologies are read through each other to create new patterns of understanding that emerge from methodological entanglement rather than separation, providing a robust framework for investigating how students and devices come (and stay) together in educational contexts.

2.10. Summary

In this chapter I have, first of all, defined Entanglement as a complex system of engagements, hybridities, and interdependencies amongst the human and nonhuman components of phenomena that create a flow of agencies. Then, I have presented a review of the current literature in what I argue are the fundamental paradigm-shifts that arise from the dynamic of the Two Schools. The Literature review is organised into four threads (Philosophical, Technological, Cognitive Shift, and Material engagement) plus the methodological framework. In the Philosophical Thread I have presented how philosophical understanding in relation to the centrality of the human and the periphery of technology are being challenged by the posthuman and postdigital movement, creating a fertile landscape for flat, relational agency. However, such movement is being challenged by our inherited Cartesian habit of mind. Therefore, this thread also presented a viable alternative in the form of Monism. In the Technological Thread I have explored how technology has a more central and articulated role in human experience than previously thought, and how changes of Technological Systems bring about a change in our relationship with the world, since they operate as ontophanic matrices. The Cognitive (Shift) Thread looked into how the cognitive science metaphor and the computer metaphor conflated into the construction of the dominant metaphor of cognition. It also presented how, supported by the cognitive paradigm and its ‘intra-cranial’ understanding of cognition, school has ignored the role of the body and the environment in cognitive phenomena. As an alternative, embodied and enacted approaches are presented. The final thread, Material Engagement, is a corollary of the previous ideas. It presents the need to recognise the importance of materiality, presented as the idea of flat relational ontologies and an understanding of material engagement and material agency.

In this ecological context, I presented the fundamentals of micro phenomenology and micro ethnography as methodologies that enable the collection of data on specific experiences from the perspective of the first person whilst still providing a rich description of the material and of the social situatedness of that experience. Finally, I presented a synthesis of the literature review and the theoretical framework underpinning this study. In the next Chapter I discuss the methodological approach in more detail.

Chapter 3. Methodology

3.1. Introduction

This chapter begins with a summary of the research gap that was identified in the literature review. This is followed by a discussion of the methodological approach used to address the research questions. The choice of approach was motivated by three challenges involved in studying the proposed issue: the colonisation of the future; the propagation of particular metaphors in the discussion and perception of Educational Technology (EdTech); and the prevalence of narratives that overestimate the desire for technologically driven interventions and ignore established practices. Then, after introducing my research questions, I explore the qualitative underpinning of this research and present a qualitative interpretive research design articulated under an onto-epistemology approach in which both the students' description of their unfolding experience of learning with digital devices and the student-device relationship sit at the core of the inquiry. Next, semi-structured interviews and thematic analysis are introduced as the data collection and analysis methods used. The chapter concludes with some ethical considerations and a positionality statement.

3.2. Research Background

This study emerges from the recognition of a gap in both knowledge and practice in terms of the role of digital devices in classroom learning. Thus, based on my experience as an educator, I could observe a disconnect between best practice guidelines and what students did when they were using digital devices for learning. This highlighted an inadequacy in current teaching practice in relation to the integration of digital learning in schools (as discussed in Chapter 1: The Tale of Two Schools). Informed by this inadequacy, I reviewed relevant literature, from which I could identify a lack of educational research concerning digital technologies in the classroom that is positioned at the intersection between embodied cognition and material agency (as explored in Chapter 2 Literature Review) from the perspective of the student-device relationship.

The methodological decisions that shape this study took into consideration three important conceptual challenges to addressing this identified gap: (1) the colonisation of the future; (2) the propagation of particular metaphors in the discussion and perception of EdTech; and (3) the prevalence of narratives that overestimate the desire for technologically driven interventions and ignore establish practices. Regarding the colonisation of the future, Niklas Larsen (2020) suggested that most efforts to think about the future attempt to navigate uncertainty by making sense of its complexity whilst remaining relevant to their consumers and citizens. In the process of doing so, they end up colonising tomorrow with the ideas of today. The prevalence of these narratives is clear in, for example, the work of Ferreira et al. (2020), which examined the adoption and implications of data-driven educational technologies in Brazil. Their work suggests that this adoption enforces a form of neo-colonialism where some of the commercial and exploitative motives behind the promotion of these technologies propel conceptual metaphors that shape how educational technologies are discussed and perceived. Similarly, Weller (2020) points out how EdTech is “remarkably poor at recording its own history and reflecting critically on its development” (p. 4). His history of educational technology contrasts with the often ahistorical and disruptive narratives that tend to overestimate students' desire for technology-driven educational experiences and ignore the nuanced and established practices within educational institutions (Weller,2020), such as that of MOOCs (Massive Open Online Courses).

These three theoretical challenges support the assumption that educational technology narratives lack a student perspective (Selwyn et al., 2024), and that research is often focused only on the effectiveness of the interventions and not on the relationship between the learner and the technology (Bennet, 2019). Thus, there is a need for research that is (1) focused on the first-person experience of learning with digital devices; (2) located in the classroom and its complex practice; and (3) from an agnostic perspective towards type of devices and/or platforms. My research aims to fill this gap in knowledge and practice whilst avoiding the entrapments of the three challenges mentioned before by means of careful methodological selections.

The focus of my inquiry, therefore, is to investigate the experience of learning using digital devices not from the perspective of the academia or the educators, or even from that of technology platforms, but from the learners’ description of the unfolding experience between them and the digital device. To that end, I set myself to explore and describe the structure of that entanglement as described in first-person recounts of these events, in the complex open environment of the classroom.

3.3. Research Questions

The research in this study is organised around two main research questions: the first focuses on identifying the structure (or hallmark) of the experience; and the second is concerned with linking this structure with current (or future) educational practice. Therefore, the research questions are:

1. *What is the nature of the entanglement between secondary school learners and their digital devices?*
2. *What are the implications of this entanglement for learning in secondary schools?*

3.4. Qualitative Underpinnings

An important aspect of this study has been the exploration and review of different inquiry paradigms and research traditions within educational research in order to understand and contextualise my own inquiry. This stage of my research presented me with different basic beliefs systems. Each of these is based on ontological, epistemological, and methodological assumptions that represent a particular worldview (Guba & Lincoln, 1994). Those basic beliefs can be defined based on the answers to three fundamental questions: (1) What is the form of nature of reality, and what is there that can be known about it? (ontology); (2) What is the nature of the relationship between knower and what can be known? (epistemology); and finally (3) How can the inquirer go about finding out, whatever he/she believes can be known? (Guba & Lincoln, 1994).

In educational research, there are two main approaches: (1) quantitative, characterised by hypothesis testing and the identification of patterns of association amongst –primarily– numerical data, and (2) qualitative, which "espouses the view that the world consists of ideas" (Cohen et al., 2018, p. 9). This world is partially constituted also by the researcher themselves, and the negotiations of meaning amongst participants, which also include the researcher. In this qualitative perspective, there is no single objective truth waiting to be discovered through quantitative research. Instead, reality is understood as something that is created and maintained through the shared agreement and understanding of the people who experience it. In other words, the world does not exist independently from those whose consensus holds it. This idea resonates with the research interest and with the micro phenomenology principle that our experience is somehow transfigured or distorted by narratives that predetermine or condition the way in which we perceive those experiences (Petitmengin, 2017; see Section 2.7.7.2 in Literature Review for a more detailed explanation of micro phenomenology).

Following Hammersley (2013), ontologically, the present inquiry regards people as meaning-making beings who make sense of their context and act through their interpretations. These interpretations are culture and context-bound, resulting in a reality that is inevitably multiple and constructed. Epistemologically, behaviours – and therefore data – are understood to be socially and culturally situated, and the assumption of this research field is that they mutually shape each other. One of the main implications of this situatedness is that social phenomena (Bourdieu et al., 1991) can be at times contradictory due to the multiplicity of interpretations and ways of experiencing it. This research, therefore, focuses on interpretations and accounts of these multiplicity of experiences.

The methodology of qualitative research requires descriptions of behaviours that include not only observational data but also unobserved factors, acquired in natural, undisturbed and uncontrived settings (Cohen et al., 2018). Whilst at the heart of all qualitative research is the description of subjective experiences and interpretations (Willig, 2017), phenomenological research's central feature is its commitment to the subjective lived-experience of the participant. In other words, my research focuses on what these experiences mean to the participants rather than what they are. By utilising open-ended and unstructured interviews (Marshall & Rossman, 2016), my study aims to elicit the meaning of these experiences from the participants own perspective while minimising interferences from preconceptions and a-priori narratives. In addition, since ethnographic research seeks to “create as vivid and analytical reconstruction as possible of the culture of groups being studied” (LeCompte & Preissle, 1993, p. 235), my research also focuses on values, beliefs, and practices (Cohen et al., 2018) as a way to investigate the worldview of the participants in order to move from data and description to “explanation, suggestion of causation, and theory generation” (Cohen et al., 2018, p. 293).

The present research primarily uses a qualitative-phenomenological interpretive methodology coupled with an ethnographic one to explore the first-person voice and the socio-material practices surrounding the student-device relationship. Whilst the micro phenomenological approach is used to explore the unfolding of particular experiences of learning with digital devices, the socio-material micro ethnographic approach is used to contrast the phenomenological first-person account with an analysis of the socio-technical context of the entanglement (Fenwick et al., 2015). In this double loop of interrogation (Gaete Celis, 2019), I go in-and-out of the analysis through the implementation of an iterative approach to interrogating both the data and my own observation. This is achieved by micro phenomenologically analysing the transcribed experience as well as the experience of the micro phenomenological analysis itself, hence locating myself in an epistemology that recognises the observer as an active part of the observed. This dynamic is mirrored in the micro ethnographic approach via the use of reflexivity in the thematic analysis (Braun & Clarke, 2022).

Petitmengin et al. (2018) placed micro phenomenology in the phenomenological Husserlian descriptive tradition (Husserl, 1970), and some authors argue that it introduces “binocular” synchronic and diachronic axes as a way to avoid excessive interpretivism from the researcher (Gaete Celis, 2019). However, the present study follows Shear and Varela’s (1999) understanding that there is “no neutral approach” but an interpretive framework. This study, therefore, adheres to a posthuman methodological approach, in which the researcher and the research are seen as entangled (Ceder, 2020) in a dynamic relationality (Barad, 2007) which makes the observer and the observed inseparable and even inter-constitutive.

3.4.1. An Onto-Epistemological Approach

The present study understands that positioning research under a particular paradigm offers the researcher a set of strategies to approach phenomena coherently. However, in doing so, it articulates explanations from a particular set of assumptions. This allows researchers to focus on what the research is about and not make a priori decisions that sometimes oversimplify the phenomena under investigation (Pring, 2015). However, paradigms should not necessarily drive the research (Cohen et al, 2018); the research should be driven by its own purposes, instead. This is why an onto-epistemological approach emerges as an alternative to what some would say are the established research frameworks in the social sciences that promote particular interests that ensure that the knowledge produced through them is always situated in particular knowledge hierarchies (Blackmore, 2022; Harding, 2001; Purkayastha, 2021).

The question of onto-epistemology is explored in Chapter 2 (Literature Review, Section 2.3.2) and I critically engage with it in Chapter 8 (Discussion, Section 8.2.2). This inquiry’s resonance with onto-epistemology emerges not only from the influence of the work of Karen Barad (2003, 2007, 2014, 2020) or Simon Ceder (2020), but also from my affiliation with critical pedagogy (Freire, 1996; Giroux, 2018; Milne, 2016) which tends to rethink assumptions in educational practice through an approach of thoughtful understanding of specific contexts (Christensen & Aldridge, 2013). Moreover, some refer to this turn towards onto-epistemology as a revolution (Tillers, 2011) that rejects the mind-body dichotomy, which central to the current investigation.

Moreover, separating epistemology from ontology is just an echo of a (dualistic) metaphysics that opposes human to non-humans; subject to object; and mind to body (Barad, 2007). Moreton-Robinson's (2011) genealogy of onto-epistemology traces the development of ontology and epistemology separation from each other to Cartesian tenets that separate mind and body (knowing and doing). An onto-epistemology understanding of phenomena, therefore, requires a level of integration between knowing and doing, but also between being, doing, and knowing (Whatman et al., 2023), that rejects traditional Cartesian dualism.

In education research, onto-epistemology offers an approach to inquire into what constitutes ways of knowing, forms of action, and ways of relating to one another (Mainardes, 2022; Runninghawk Johnson et al., 2023). It addresses epistemic injustices (Fricker, 2007) by tapping into different realities to reveal different worlds via a practice lens. Whatman et al. (2023) proposed a model of education research based on a practice called "Pedagogy, Education and Praxis" (PEP). This approach questions prefigured knowings (Kemmis et al., 2013) that lead to unquestioned research practices as a way to focus on the dialectic between humans, practices, and others. This decolonising of the research method intends to transform misinterpretation into informed consciousness (Lincoln & Guba, 2016) by rearticulating action, being, and knowing. An onto-epistemological approach that rearticulates action, being, and knowing whilst addressing epistemic injustices by revealing different worlds via a practice lens provides the present study with an alternative and novel approach to educational research that allows for a multifaceted, pluriperspective inquiry into phenomena. By integrating action, being, and knowing, knowledge is no longer disembodied and non-local, but the opposite. Furthermore, the material and social world of engagements becomes intrinsic to the description of a phenomenon; that is to say, they are entangled, the same way the cognition, technology, and the body are entangled in this study.

Traditional research is designed around and alongside axiology, ontology, and epistemology as aligned yet separate aspects of what is sometimes described as the metaphysics of constructivism (Lincoln & Guba, 2013). This separation can be traced back to Cartesian disembodied epistemologies, where "bodies do not matter in the production and sharing of knowledge, because it is disembodied" (Moreton-Robinson, 2011, p. 423). However, researchers such as Tuiwai Smith (2022), Kincheloe and McLaren (2011), and Nakata (2007) suggested that by adopting an onto-epistemological perspective, *who we are* and *how we came to know* are turned into explicit and inseparable (Whatman et al., 2023). Onto-epistemology, therefore, enables researchers to understand the dynamic that privileges certain types of knowledge over others. An important aspect of the present study relates to the identification of a gap from the double perspective – a gap in practice and a knowledge gap. At the same time, a lack of first-person voice in the complex context of the classroom was also identified. Addressing these gaps means addressing discursive challenges that include the colonisation of the future with the ideas of today; the proliferation of metaphors that shape the perception and discussion of education technology; and the existing narratives that overestimate students' desire for technology-driven practices whilst ignoring the nuances of long-established practices. Moreover, by creating spaces where diverse forms of knowing are legitimated (like those of the learners and the education practitioners) the present study indirectly advocates for the inclusion of research tools that capture not only the voice of those who are part of the experience (micro phenomenology) but also a mapping of the practices and belief systems (narrative analysis) that give rise to particular social practices (micro ethnography).

3.4.2. Reflexivity Through an Onto-Epistemological Lens

Within this onto-epistemological framework, the concept of reflexivity itself requires some reconceptualisation. Traditional qualitative research has long emphasised reflexivity as a means for researchers to acknowledge their positionality and potential biases (Berger, 2015). However, both Barad and Haraway offer more radical reimaginings of what reflexivity might entail when we move beyond human-centred, representationalist approaches to knowledge production.

Haraway's (1988) influential concept of situated knowledges fundamentally challenges the notion of the detached, objective observer. For Haraway, reflexivity is not merely about acknowledging the researcher's position but about recognising that all knowledge is produced from somewhere, by someone, and that this *somewhere* is always already entangled with power relations, material conditions, and embodied experiences. She contends that:

> feminist objectivity is about limited location and situated knowledge, not about transcendence and splitting of subject and object. It allows us to become answerable for what we learn how to see. (Haraway, 1988, p. 583).

This understanding of reflexivity moves beyond introspection to encompass what feminist new materialist scholars term response-ability (Bozalek & Zembylas, 2023), the ability to respond to and be accountable for the knowledge we create and the worlds we help to enact. Barad's (2007) agential realism extends this critique even further, proposing that reflexivity must account for the material-discursive practices through which boundaries between researcher and researched are enacted. For Barad, reflexivity cannot be understood as a simple turning back on oneself; rather, it involves recognising that "we are part of the world in its ongoing intra-activity" (p. 184). This diffractive approach to reflexivity acknowledges that researchers are not outside observers but are always already part of the phenomena they study, co-constituted through the very practices of research.

Both scholars emphasise that reflexivity cannot be reduced to a cognitive exercise of self-awareness. Instead, it requires attention to the material-semiotic practices through which knowledge is produced and the ways in which these practices are always already political. Barad (2007) argues that " knowing is a direct material engagement, a practice of intra-acting with the world as part of the world in its dynamic material configuring, its ongoing articulation" (p. 379). This perspective rejects the notion that reflexivity is about stepping outside oneself to gain critical distance; rather, it is about recognising our entanglement within the very phenomena we seek to understand.

This reconceptualisation of reflexivity has profound implications for the present study. Rather than simply positioning myself as a reflective researcher who acknowledges their biases and background, the onto-epistemological approach requires recognising that the very boundaries between myself as researcher, the students as participants and the digital devices as objects of study are enacted through our research practices. The micro-phenomenological interviews do not simply capture pre-existing experiences but participate in the ongoing becoming of those experiences. Similarly, the ethnographic observations are not neutral recordings but material-discursive practices that help to configure the very phenomena they purport to study.

This understanding aligns with the study's commitment to avoiding the colonisation of the future with present-day assumptions. By recognising that research practices are always already world-making activities, the onto-epistemological approach to reflexivity demands attention to the kinds of worlds we are helping to enact through our research practices. This perspective fundamentally shapes how the diffractive reading of micro-phenomenological and micro-ethnographic findings is approached, recognising that this reading is itself a material practice that participates in the ongoing configuring of student-device entanglements.

3.5. Research Design

This section introduces the research design of the study. This design was framed to address the research questions presented in Section 3.3. The following sections cover general aspects of the methodologies used to carry out the present study. Chapter 4: Intervention explores how these methodologies were applied to this research by providing a detailed description of the data collection and analysis processes used.

3.5.1. Data Collection

Aligned with the requirements of interpretative qualitative research, both micro phenomenology and micro ethnography demand data to be collected in setting where participants can speak on their own terms (Cohen et al., 2018). The micro phenomenological Interview (MPI) was selected as the main method to collect the students' voices as a way to address this concern. Two of the main tenets of MPI are, first, to disregard any section of the interview that may have been led by the researcher's questions; and, second, to finalise all MPI with a corroboration of the participants' recount and an offer to allow participants to check and potentially change the way they presented their position in the interview (Valenzuela-Moguillansky & Vásquez-Rosati, 2019). At the same time, as context is heavily implicated in meaning (Ellsworth, 1977; Kaplan & Talbot, 1988) this study is set in the natural setting where they occur: the classroom. Both the lesson observations and the MPI were carried out in the students' environment; while special attention was put into not interfering (other than by being present) neither with the planning or delivery of the lessons observed, nor the students' response to the lesson requirements.

Although a number of data collection methods were used, most of the data analysed was collected via three main tools: (1) the Micro phenomenological Interviews; (2) a digital survey; and (3) video-recording of the participant classes.

The full list of data-collecting methods is as follows:

1. Video-recording of participant lessons;
2. Researcher's observation notes;
3. The Generalised Observation and Reflection Platform (GORP) observation timeline;
4. Post observation digital survey (Google Form);
5. Micro phenomenological interview [transcripts]; and
6. Micro phenomenological researcher interview notes.

The video recording comprises both the video recording of the observed lessons and that of the micro phenomenological interviews. Chapter 4 (Intervention) discusses in more detail the recording protocols. The main purpose of the video recordings is to allow for the establishment of a temporal link between a variety of experiences or within a single experience. However, in this study, the diversity and uniqueness of experiences prevented the use of video recording in this way, since the study did not use a single experience that could be linked to external temporal markers but rather single activities occurring at various times. Video recordings were mainly used, therefore, as a way to register the overall context of the experiences from where the data was collected, and to place the experience within the lesson recorded. In the context of this study, the video recordings took the format of class observation recordings (multiple cameras) and MPI recordings (single camera). They complemented the data gathering by providing a visual detailed record of learners' interactions with their devices and/or of physical non-verbal interventions during observation or interviews. This video record could also be incorporated into the MP analysis as a way to identify/confirm the moments of the experience as a possible way to trace the links (if any) between the diachronic phases or synchronic structures and the learners' interactions with their devices.

As the lessons were being recorded, I took observation notes capturing initial ideas, possible avenues of inquiry, and salient features of the students' experiences. Erikson et al. (2012, p. 9) pointed out that "field notes are important because they involve the critical acts of sense making and interpretation, which inevitably have some kind of bearing on the research findings and results". The purpose of these notes, thus, was to inform the construction of the subsequent MPI interviews and to start identifying possible patterns or trends. They were recorded in a very messy, unfinished, and personal style as handwritten notes on my iPad using the Notability application. These notes were not included in the analysis and were only used to make sense of the situation I was observing and to help me reconstruct the context of a particular experience when needed.

The Generalized Observation and Reflection Platform (GORP) is a web-based platform for carrying out classroom observations using customisable protocols. It allows the observer to, first, create an observation protocol displayed as a series of digital buttons. The activation of those buttons creates both a timestamp and an event count of whatever is observed. Appendix B section b features the basic template I designed for my observations. I used GORP as a way to create a common framework of observation across different classes and to ensure that a similar set of information and insight were gained from the set of different experiences included in this study. I piloted this platform in my own practice when tracking pedagogical approaches across the school and it proved to be a successful tool to actively direct the attention of the observer towards particular features of the lesson. Just like the observation notes, it allows the observer to start making sense of a new environment which can be fast-changing at times.

After the observation and recording of the lessons, a brief Digital Survey was sent to all participants (see Appendix B section c). The digital survey was sent to the teacher volunteer, who then uploaded it to the class' Google Classroom. Completion was optional. After the posting date, students were sent a single reminder within a week to complete the survey. This digital survey (in the format of a Google Form) included four core questions oriented to identify (1) how much they had used their device during the lesson; (2) how important for their learning the use of their device had been; (3) in what way their device had supported their learning and, finally; (4) what device they had used. Other questions were included to ascertain the class they were part of and if they would be willing to participate in a short conversation (to invite them to take part in the MPI).

The principal method of data collection was the micro phenomenological Interview (MPI). MPI is a method inspired by *l'entretien d'explicitation* (Vermersch, 1991) and adapted to the cognitive sciences (Petitmengin, 2006) in order to explore a singular, concrete experience from the perspective of the first person. The MPI offers a systematic way to identify "experiential invariants which constitute the structure of the experience" (Petitmengin et al., 2018, p. 692) by iteratively unfolding the structure of the experience and refining its description over two different axes: synchronic and diachronic. Whilst the diachronic description is concerned with the unfolding of the experience over time, the synchronic looks into the structural features of it. This granular observation allows the subject to become aware of their own experience by stabilising their attention on the "how" rather than "what" (Petitmengin, 2006), as a way to bridge the chasm between the qualitative subjective aspects of experience and the physical processes (Petitmengin, 2017). The MPI aims at eliciting an *épochè* (bracketing) by focusing on a singular experience and avoiding generalities. It re-creates a chronological reorganisation of the description by evoking the experience to the point that the past becomes present: a diachronic description of the experience that focuses on the moments of its unfolding and a synchronic description that observes the structural characteristics at a given instant.

I used the micro phenomenological interview as a technique to guide the evocation of a single experience (a particular use of a digital device for learning on a particular day for a particular purpose) to help the interviewee piece together said experience. The MPI allowed me to move away from the "what" and towards the "how" as learners were asked to describe the sequence of moments of the experience first and then the structure of those moments. The aim was to create a cartography of the experience. MPI can be described as a guided retrospective introspection in which the attention of the interviewee is guided through open, noninductive questioning (Ollagnier-Beldame & Cazemajou, 2019). Follow-up questions depend on the responses and intend to redirect the attention of the subject away from generalisations ("every time I…"; "we normally…") or preconceptions ("you have to… in order to…") and towards questions in order to evoke the embodied posture of speech (evocation) to describe the micro-dynamics of actions and processes. MPI produces a recollection of both central actions (those directly experienced by the subject) and satellite information (the context of the experience, the purpose of actions and comments, beliefs, judgements, and justifications). Satellite information were excluded from the MP analysis, but they were still meaningful for the interpretation of the actions that were analysed. The micro ethnography data analysis approach (described further in the next section), on the other hand, offers the possibility to incorporate satellite information as a way to explore the socio-material entanglement that constitutes an experience as well as the way in which artefacts embody concepts (Barad, 2007).

Overall, about 180 students accepted the invitation to be participants in the research's first stage (observation), across seven different classes in a variety of subjects. From those, 16 students were invited as key participants, 9 of which accepted the invitation and undertook MPI. Purposive sampling was used to move away from random sampling and ensure a strategy is used that maximises the limited research resources available (Campbell et al., 2020). Purposive Sampling helps to take into account a wide breadth of factors rather than a defined number of variables to understand the phenomena at stake, and "enables the full scope of issues to be explored" (Cohen et al., 2018, p 289). By using purposive sampling, I had to rely on my own judgment when choosing the key participants in the study. To do so, I considered different cases of purposive sampling, such as typical case, extreme or deviant case, critical case, maximum variation sampling, homogeneous sampling, or theoretical sampling (Black, 2023). Purposive sampling relies on the researcher's judgement to select participants with diverse characteristics. This is done to ensure the presence of maximum variability within the primary data. "A maximum variation sample is constructed by identifying key dimensions of variations and then finding cases that vary from each other as much as possible" (Suri, 2011, p. 67).

For this particular research, I used the heterogeneous approach (maximum variation sampling) to ensure the presence of maximum variability within the data (Black, 2023). This maximum variation/heterogeneous purposive sample provided me with a diverse range of cases relevant to the particular phenomenon, to provide as much insight as possible into the phenomenon under examination and to construct a robust view of the issue. In this research, this maximum variation is reflected (1) in the number of participant variables (age, gender, ethnicity); (2) in the scope of subjects included (English, History, Art, Photography, Chemistry, Media Studies); (3) in the setting of the experiences included (the classroom or somewhere else); (4) in the type of devices included (laptops, tablets, drawing tablets, Ipads); (5) in the level of expertise displayed by the participants (from advanced users to casual users); and (6) by the implicit care of including the whole experience (and not just those aspects relevant to my research) presented in the participants' recounts. This information was collected in the observation notes.

3.5.2. Data Analysis

This section presents the analytical procedures of this study. It is organised in three sections. The first two sections present micro phenomenology and micro ethnography, the two main methodologies used to analyse the data. The third refers to diffraction, the theoretical lens put in place to bring those two methodologies into a dialogue. Figure 5 shows the data collection methods (bottom) and the type of evidence they produce. The central collection method (MPI) serves as the base for both the MP and ME analysis. While each analysis was conducted independently, they come to a dialogue through the use of a diffractive theoretical lens (top).

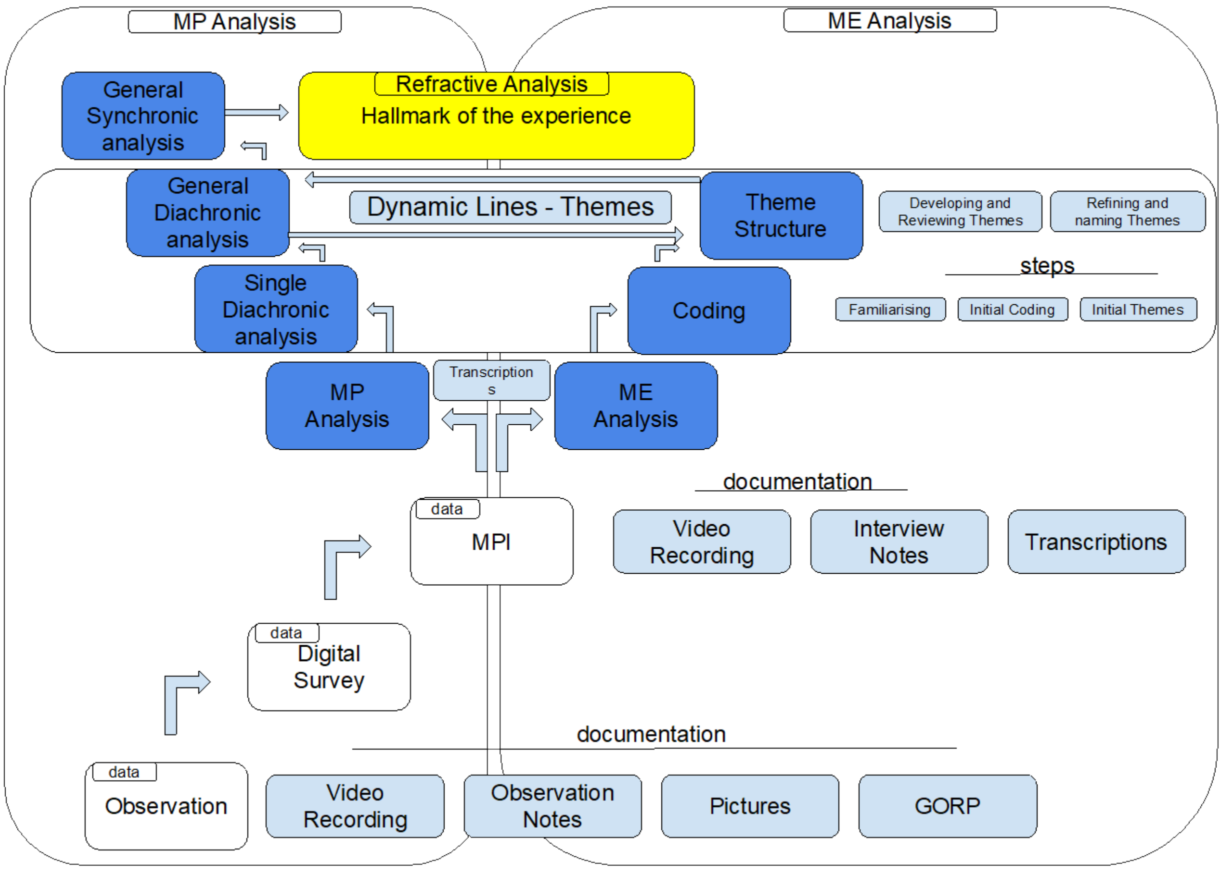


Figure 5

Data collection methods

3.5.2.1. Micro Phenomenology Data Analysis.

Despite almost 40 years of research on technology in education, we still do not know what happens when students and devices come together (Lai, 2018). The main purpose of the present study is to explore this issue, particularly since, the perspective of the first person (the students' voice) seems to be missing from this academic field (Bennett, 2019, Selwyn et al., 2024). While MP analysis can be categorised as a second-person perspective since the data is gathered through another person, namely the researcher (Ollagnier, 2019), it enables access to the experience as lived by the first-person. The MP analysis in this study is heavily influenced by the work of Camila Valenzuela (Petitmengin et al., 2018; Valenzuela-Moguillansky & Demšar, 2021; Valenzuela-Moguillansky et al., 2021, 2021b) and Maria Gaete Celis (Gaete Celis, 2019). Camila trained me both as an interviewer and in methodological analysis. Valenzuela and Vasquez (Valenzuela-Moguillansky & Vásquez-Rosati, 2019) proposed that a model of analysis consists of 15 stages organised in a double loop of abstraction. The first 9 stages refer to the analysis of a single experience, whilst the last 6 stages refer to the comparison of structures from a group of experiences. Each stage involves a greater level of abstraction in order to identify the phases (moments) and the types (structures) of a (collection of) experience(s). Table 1 presents the organisation of the fifteen stages delineated by Valenzuela-Moguillansky and Vásquez-Rosati, (2019, p. 125). The term "specific" in the first column refers to the analysis of a single experience (a specific experience of a single individual). The term "generic" refers to the analysis of a group of experiences (collected from either a single person or from multiple individuals).

The micro phenomenological analysis looks at the experience from two perspectives: diachronic and synchronic. Whilst the diachronic analysis looks at the experience from a temporal perspective, the synchronic analysis looks at a single moment of the experience to describe it.

Table 1

Distribution of the fifteen stages of the MPI analysis procedure

Section	**Stage Number**	**Stage**	**Description**
Data preparation	1	Transcription	Verbatim, orthographic transcription, including specific gestures.
	2	Refining the data	Distinguishing between core and satellite information.
	3	Selecting the text for analysis	Selecting the fragments describing the procedural dimension of the experience.
Specific diachronic analysis	4	Re-sequencing of the description	Restoring the chronology of the described experience.
	5	Identification of specific diachronic units	Iterative interrogation of the data to identify a set of processes (sub-phases) and actions (sub-sub-phases).

	6	Definition of the specific diachronic structure	Organisation of the phases and sub-phases to construct the representation of the diachronic structure of the experience.
Specific synchronic analysis	7	Grouping of the utterances by topic	Group the utterances by topic.
	8	Identification of the specific synchronic units	Iterative interrogation of the data to identify synchronic categories (thematic, structural, etc) of different levels of abstraction
	9	Definition of the specific synchronic structure	The categories identified in the previous stage are organised and represented to build the synchronic structure of a moment of the experience.
Generic diachronic analysis	10	Alignment	'Alignment' of specific structures according to the external frame of reference.
	11	Identification of generic diachronic units	Aligned phases are grouped by similarity.
	12	Definition of generic diachronic structures	Representation of all the identified diachronic units into a single structure or types of structures.
Generic synchronic analysis	13	Interrogation of utterances and grouping by topic	Listing the utterances of all the interviews that correspond to the particular 'moment' to analyse. Then follow a procedure similar to that of the specific synchronic analysis.

	14	Identification of the generic synchronic units	Iterative interrogation to identify categories (thematic, structural, etc.) of different levels of abstraction.
	1	Definition of generic synchronic structures	Organisation and visualisation of the generic synchronic structure.

Note. Adapted from Valenzuela-Moguillansky & Vásquez-Rosati, (2019, p. 125).

The aim of this study is to be able to describe the hallmarks (or structure) of an experience (learning with digital devices) and to describe the dynamics of the moment of connection between students and devices. To arrive at this description, each singular experience had to be analysed diachronically first to identify the steps or moments of each one of the single experiences (see Appendix C section d for an example of a Singular Diachronic Analysis). Once identified, these individual structures are then aligned to find commonalities, until a common hallmark (or structure) emerges: the general diachronic structure. By re-analysing all of the utterances or statements within a particular moment of the general diachronic structure, it is possible to identify the general synchronic structure (although no synchronic analysis was performed on the data).

The micro phenomenological analysis in this study mostly follows Valenzuela-Moguillansky & Vásquez-Rosati (2019) design. However, as I will present in Chapter 4: Intervention, inventions and adaptations were introduced in order to allow the research intentions to guide the analysis. The main points of differentiation were (1) two sets of diachronic analysis (at the level of the general experience and then again at the level of the moment); and (2) the description of the synchronic structure extracted as a diffractive articulation between the two methodologies. This engagement of micro phenomenological analysis and micro ethnographic coding in a critical dialogue, where the narrative analysis themes are used as (thematic) dynamic lines to articulate both methodologies transversally, represents a key methodological contribution of this study.

3.5.2.2. Micro Ethnography Narrative Analysis.

Although MP offers a consistent methodological approach to explore the single experience from the perspective of the first person, part of the description of that experience concerns the actual dynamic of material engagement with the artefacts themselves. The main reason for the inclusion of the ME approach in this study was to document interactions with artefacts and ways in which they might embody concepts or entrap agencies, as a way to understand the complex relationship between people and things or, in the context of this research, between learners and their devices. Moreover, using narrative analysis offered an opportunity to contrast meaning-making from two different perspectives: embodied practice (micro phenomenology) and narratives (micro ethnography).

Narrative analysis is an umbrella term that includes several approaches (Braun & Clarke, 2021; Esin, 2011) whose unit of analysis is the story. Different approaches focus on different aspects of that story, such as structure, content, or performative function. In the case of this particular research, Reflexive Thematic Analysis was selected (Braun & Clarke, 2006, 2022). Reflexive Thematic Analysis (RTA) "is a method for developing, analysing and interpreting patterns across a qualitative dataset, which involves systematic processes of data coding to develop themes" (Braun & Clarke, 2021, p. 4). A core conceptualisation of RTA is its consideration that the analysis occurs at the intersection of the dataset, the context, and the researcher's skill and locatedness (Braun & Clarke, 2021). The process of RTA implies a series of 6 phases. The term "steps" is intentionally avoided because, whilst the word "step" has a connotation of linearity and segmentation, the term "phase" better evokes the idea of a progressive and recursive process (Braun & Clarke, 2021, p. 36). The six phases of RTA are: (1) Familiarising yourself with the dataset; (2) Coding; (3) Generating initial themes; (4) Developing and reviewing themes; (5) Refining, Defining and naming themes; and (6) Writing up.

Both the main experience (the one recorded at school) and the chosen experience (the one selected by the student) in their entirety were considered for the narrative analysis. I selected a thematic model (Riessman, 2008) to gather the main ideas being used to describe the learners' dynamic of learning with digital devices. The point, rather than focusing on the strategies used to construct a narrative around it, was to identify the main themes and (in line with a micro ethnographic approach) establish a close dialogue to theory (Alvehus & Crevani, 2022). Another reason for a focus on themes was the early realisation that, aside from the first-person voice, there seemed to be a very strong institutional voice permeating the learners' narratives (particularly in relation to assessment processes and the importance of handwriting). Thematic analysis afforded me a way to isolate these interferences and contrast them with other considerations. The thematic analysis was conducted on the verbatims from the MPI. The transcripts containing core and satellite information were iteratively coded using MAXQDA, a (digital) qualitative research tool that can be used for coding and analysing source materials as well as creating data visualisations. The data was analysed iteratively. After the familiarisation reading, a first round of analysis was conducted to identify Vial's (2018, 2019) dimensions of the digital in the transcripts of the interviews (Appendix C section e). After that, successive iterations of coding generated initial themes that were developed and redefined. Data visualisation of the relationship of code presence in particular segments (particularly that of the presence of Vial's dimensions of the digital) was instrumental to the progression of the analysis of the data.

3.5.2.3. Diffracting Reading of ME and MP.

This study is located in a posthuman theoretical approach. It proposes a de-centred philosophy that views researcher and the research object as entangled and inseparable (Ceder, 2020); that the human subject is not necessarily the point of departure for analysis (Springgay, 2015). This philosophy also adopts a flattening approach to affect, materiality and relationality (Ceder, 2020, p. 48) that moves beyond the metaphysical subject/object dichotomy (Murris & Bozalek, 2019). Some of the posthuman methodologies that explore these ideas are Transposition (Braidotti, 2006); Transversality (Yuval-Davis, 1997); and Cartographies (Deleuze & Guattari, 1977). Another such methodology is Diffraction. Although originally introduced by Haraway (1992), it has been developed and popularised by Karen Barad (2007) and it is based on the physical phenomenon of diffraction. In physics, diffraction is the process by which waves are spread out after passing through an aperture, which creates interference between the waves, producing new patterns. It is this interference and overlapping that leads to the creation of new patterns, or superposition, that lies at the heart of diffraction (Barad, 2007).

Originally developed as a methodology to analyse texts, a diffractive reading means reading a text through another "to engage aspects of each in dynamic relationality to the other" (Barad, 2007, p. 93). And it is in this entanglement that the core notion of diffraction resides. As explored in Section 2.3.2, one of the tenets of relationality is that there are no properties that precede phenomena. The researcher and the object of study are relata that only come into being through their intra-action. Diffractive analysis, therefore, both creates knowledge and reality (Ceder, 2020). However, most importantly, in a context of intra-relationality, a Diffractive reading becomes much more than the sum of parts; it becomes a pragmatic and creative methodology to generate new thought (Ceder, 2020), Therefore, following Gibson (2023, p. 273), I used diffraction "as an analytical research approach [to bring] the research data together in a way that afford[ed] the opportunity to look at it concurrently, rather than analysing the data sets in an isolated, individualistic and linear way". That is to say, to read a set of findings of MP though the lens of ME, and vice versa. The main methodological diffractive tool used was the use of the themes of the Narrative Analysis as dynamic lines of the Generic analysis. This diffractive reading allowed me to also corroborate the validity of the data and the analysis by providing an integrative strategy where two different angles of inquiry overlapped to (independently and collectively) explain phenomena. Moreover, the diffractive reading of these findings added an extra aspect of sense-making and dimensionality to the results.

3.6. Data Validity and Trustworthiness

Validity and reliability are central measures of the quality of a study. Although the strategies used to establish the validity and reliability of a study differ from approach to approach (Cohen et al., 2018), they are a central requirement for any type of research. Thus, while some link validity to the ability of an instrument to account for or measure what was intended (Winter, 2000), others use the logical link between data and conclusion to assess the validity of a study (Ary et al., 2002). However, some authors still see in the notion of validity a positivist inheritance and propose better-suited alternatives for qualitative research, such as authenticity (Guba & Lincoln, 1989) or understanding (Maxwell, 1992; Mishler, 1990). Moreover, the term trustworthiness is often used to indicate that a piece of research is valid, and therefore worthy of attention (Lincoln & Guba, 1985). In spite of any terminology variation, there is a clear onus on the researcher to ensure that the instruments selected to describe phenomena are sound (Shadish et al., 2002); that the selection of data is rigorous (Fielding & Fielding, 1986), and that a careful traceable audit of evidence is present (Lincoln & Guba, 1985). Teusner (2016) paid particular attention to transparency (Maxwell, 1992) as a way to achieve validity through a clear understanding of the research methods. This includes both transparency in terms of reflexibility (Teusner, 2016), but also transparency achieved via validity (Maxwell, 1992).

Cohen et al., (2018) identified two main forms of validity. Internal validity refers to the relationship between elements of the research design and outcomes, whilst external validity is linked to its generalisability. LeCompte and Preissle (1993) Identified a few kinds of internal validity, such as the ability to report the situation from the perspective of the participants, the coherence of that data, the soundness of the research design, the credibility, suitability, dependability, and confirmability of the data. I can identify these elements in my research. I have intentionally selected a methodology that prioritises the first-person voice and their perspective in the experience of the phenomenon under investigation, and I have presented all findings, and not only those supporting my arguments. Similarly, the study offers a sound design and the multiple systems of recording the data ensure that it is credible, dependable, and confirmable. I have also created an auditable record of my data collection and analyses. Furthermore, Lincoln and Guba (1985) pointed out six ways to address credibility: (1) prolonged engagement with the field; (2) persistent observation; (3) triangulation; (4) peer debriefing; (5) negative case analysis and (6) respondent validation. These six elements were adopted as a way to increase credibility. However, as discussed in Section 3.4.1, this study is also attempting an onto-epistemological approach. As such, it is influenced by practice architecture research (Kemmis et al., 2014), particularly concerning the special attention paid to sayings, doings, and relatings that constitute situated practices (Whatman, 2023) whose situatedness is shaped and shapes the research practice. In its quest to deconstruct certain forms of systemic amnesia (Maldonado-Torres, 2004), practice architecture highlights the importance of researching through a practice lens, therefore validating different ways of coming to know in the world (Wilkinson, 2021). The implication of this onto-epistemological practice architecture focus in relation to Lincoln and Guba’s (1985) six ways to address credibility is that in the context of this study, these six ways are extended to include not only my (short) practice as a researcher but also my (long) educational practice.

Research, from an onto-epistemological perspective, means that “knowing and being are inextricably linked, closely guiding what we value and do” (Whatman et al., 2023, p. 43). This means that the researcher's personal history and professional background inform their practice as much as the field of research they are working in. In my case, my engagement with the community the study was situated in goes beyond the research itself. It also includes the time spent with them as an educator. I would like to, therefore, address here Lincoln and Guba’s (1985) six criteria for credibility on that premise. In relation to prolonged engagement, as an educator, I have been involved in education practice for over 15 years, and for over 6 years I have engaged in education research. I have had a sustained involvement with the community where my research is based, since I worked at the school for over 8 years. During that time, I have persistently observed and inquired into the digital phenomena from both the perspective of the educators and the learners.

Triangulation is the cross-validation of data by using different sources and perspectives (Somekh & Lewin, 2005). Denzin (1978) identified four types of triangulation: (1) data triangulation; (2) investigator triangulation; (3) theory triangulation; and (4) methodological triangulation. To account for (1), data has been sourced from a number of different classes and in a number of different contexts (subjects), including students of different ages and of varied ethnicities. Furthermore, a pilot was carried out in a different location altogether. In regard to (2), although I am the sole researcher in this study, as part of both my PhD supervision and methodological training, other investigators' perspectives have been sought and included as part of my reflexive processes.

As introduced in Section 2.5, the theoretical dichotomy between the cognitive and the enactive or embodied paradigm of cognition was a permanent consideration in the interpretation of the findings (see Section 8.2.3 for a detailed discussion). Moreover, as discussed in Section 3.5, two methodologies were utilised to analyse the data (micro phenomenology and micro ethnography). Whilst the theoretical discussion between the cognitive paradigms addresses (3); the use of two methodologies does so in regard to (4). As the analysis of the data progressed, peer debriefing was sought via interaction both with the PhD supervisors and, primarily, the ME specialists.

As this research involved a reduced number of key participants, negative case analysis, which looks to "refine a hypothesis until it accounts for all known cases without exception" (Lincoln & Guba, 1985, p. 309), was applied in order to generate the initial hypothesis and the final interpretation. Respondent validation was sought in the form of offers to present the findings back to the site where the research was carried out and sharing a website with the initial findings, but as at the moment of this thesis being written, no feedback has been received. Finally, for research to be reliable, it should demonstrate accuracy as well as precision. That is to say, if it were to be carried out with a similar group in a similar context, it should lead to similar results (Cohen et al., 2018). However, some authors suggest that reliability is essentially a positivist concept (Guba & Lincoln, 1994) or contends its use in qualitative research (Winter, 2000) and prefer terms such as credibility, neutrality, dependability, trustworthiness, or transferability. These can be achieved by providing a thick description of the contexts and methodology of a study. Such description is attempted throughout the study.

3.7. Ethical Consideration

In qualitative research, reflexivity is a central component (Berger, 2015; Cohen et al., 2018), since the researcher has a central role in the creation of knowledge. Researchers bring their own biographies to their studies, since they are "in the world and of the world that they research" (Cohen et al.,2018, p. 302). Reflexibility and positionality, therefore, are essential parts of the process in recognising that, as a researcher, I am inescapably part of the world I am researching.

3.7.1. Positionality Statement

This research is both a continuation of my master's research in education and a consequence of my professional involvement with secondary school education as a teacher, but also as a learner. My master's degree marks my first incursion into education research. Informed by action research, I investigated the dynamic of extending students' digital capabilities, mainly from the point of view that the teachers' own digital capabilities could enable or impede the development of student capabilities. The observation of high-performing secondary school learners in a (then) decile 9 school (see section 4.4 for an explanation of the term decile) in an urban area of Aotearoa New Zealand self-organising their learning processes by translating analogue note-taking with digital record-keeping further motivated me to inquire into the nature of the relationship between the students and their digital device. My research is influenced by my position as an immigrant not only to this country but also to the English language. Translating realities and systems is a natural part of my daily life as I am constantly merging different systems of representation (ethical, moral, political, social, etc.). I am also influenced by my position as an ex-faculty member within an education institution that prides itself on its record of academic achievement and adherence to 'tried and tested' methods. However, my approach to this study was mainly influenced by ideas acquired through intellectual curiosity: a belief that the body and surrounding ecosystem are constitutive parts of an individual's cognition; that education must focus on a relationality in which humans and non-humans collaborate in the concatenated construction of agency, and that the digital seems to be redefining school rather than the other way around.

3.7.2. NZARE Guidelines and Ethics Application

An application for Ethical Approval to the Auckland University of Technology Ethics Committee (AUTEC) was sought and granted (AUTEC 22/114, see Appendix A). AUT considers a participant a child only if they are under the age of 16 (Powell & Smith, 2006). Therefore, no children were interviewed or recorded for this research; instead, the study focused on senior students, aged 16 and over.

I acknowledge that I have fully complied with the New Zealand Association for Research in Education (NZARE) ethical guidelines 2012 (the sections of the document are indicated in brackets). I have adopted NZARE general principles of avoiding harm and doing good, undertaking only topics and methods for which I had the required level of knowledge and expertise (2.1), and taking into consideration the rights and interests of those involved (2.3) in a relation of mutual trust and respect (2.5).

None of the students taking part in this research were directly taught by me or were in any way exposed to a conflict of interest. The rights and welfare of learners took precedence over mine (2.6) and all actual or perceived conflicts of interest were declared and independently reviewed in order to be mitigated (2.7). Special care was paid to avoid excessive anxiety or harm to the participants and communities involved in the research as a result of their involvement, the details of the distribution of the findings (3.1). The school was offered a short findings report and the option of me presenting to the leadership team or staff about the findings. Special care was taken to avoid hindering the educational progress of any participant required to spend time away from teaching and learning activities (3.7).

All participants were provided with the option of making an informed decision in relation to their involvement with the research. Thus, a clear description of the research to be undertaken was provided (3.2), the participants explicitly consented to being involved (3.3), and all steps that were implemented to protect them from harm were explained to them (3.5). Information was securely stored and de-identified (3.6) and all participants were made fully aware of the intended use of any information collected (3.7).

All information, positive and negative (2.9), was objectively reported, open to inquiry, and expressed in a way that is accessible for those involved (2.10), clearly differentiating personal opinions and evidence from research findings (2.11). The findings were not disseminated without draft reports being made available prior for peer-review (5.2). All assistance with this research is acknowledged (5.5), and all participants and organisations involved were given a report of the research findings (5.6).

Ka Hikitia (Ministry of Education, 2008) is the document that articulates the Ministry of Education's Māori education strategy. It emphasises “knowing, respecting and valuing where students are, where they come from and building on what they bring with them” (p. 20). That means putting the students at the centre and considering their material and cultural ecosystem. By exploring students’ experiences of learning with devices, this research offers a bottom-up approach that could inform the decolonisation of the encoded demands of artifact design, since “technical design has an essential role in either maintaining or overcoming coloniality" (Cruz, 2021, p. 1847). MPI explores the disconnection between the experience and our recollection of it by challenging preconceptions, generalisations and judgements, providing an ideal territory for the exploration of decolonisation of perception (Lazem et al., 2021). However, only 0.02% of the roll of the participating school identified as Māori and as there were no Māori students in the volunteer classes, no Māori students took part in this research.

3.8. Summary

In this Chapter, I presented how arguments indicating the lack of a student's voice in educational research relating to technology in the classroom could be linked to narratives that tend to colonise the future with ideas of today, and how these ideas tend to belong to organisations and governments trying to remain relevant to their stakeholders. Then, after presenting my research questions as a way to inquire into the relationship between students, their digital devices, and the education system, I proposed and analysed the requirements of a qualitative interpretive research design under a onto-epistemological approach that rearticulates action, being and knowing, giving voice to those that are part of the process of learning with digital devices in the context in which learning happens. Finally, by arguing that who we are and how we came to know are explicit and inseparable, I explored the mechanisms for data collection and analysis from the perspective of both micro phenomenology and micro ethnography as a way to gather data on both the students' first-person experience and the material practices from which they emerge, as well as presenting a diffractive theoretical lens as a mechanism to read the results simultaneously rather than lineally. Finally, I closed the chapter with the ethical considerations and a positionality statement.

Chapter 4. Intervention

4.1. Introduction

In this chapter, I describe not only the nature of the study intervention but also how it is deeply rooted in my own practice. First, I describe the genesis of this study and give some context in relation to the educational context in Aotearoa New Zealand. Then, after considering the location, participants, and my shared history with the institution's ethos and beliefs, I discuss the study phases, as well as the challenges encountered that required me to invent new strategies and adapt my methodological approach to fit the inquiry.

4.2. The Researcher as a Practitioner

As described in Chapter 2, this research emerges from the double perspective of theory and practice. As a theoretical exercise, it is the exploration of onto-epistemological aspects of learning with digital devices in a secondary school setting in Aotearoa New Zealand. However, from a practice perspective, this study is motivated by my own experience of the disconnection between classroom practice (the Anaesthetic school articulation) and the possibilities of new approaches (the Aesthetic school). Nonetheless, it was not only my critical reflection as an educator that provoked me to pursue this research but the observation of the various strategies, assemblages and adaptations that students would trial in order to make digital learning work for them in the context of an analogue school setting. This research, therefore, is strongly and primarily located in the complex, open context of the classroom (Biesta, 2010; Taguchi, 2009) and my own historicity as a secondary school educator of over 20 years.

The aim of this research is to describe the students' experience when learning with digital devices, not in relation to what they learn, but in relation to how the experience unfolds. The MPI (micro phenomenological interview) guides the students' evocation in order to re-call the unfolding of that experience. Informed by a micro phenomenological analysis of learners' experience using digital devices, this research investigates the emergence of particular educational configurations (Biesta, 2009) in which digital devices have emerged as structures of perception and action rather than mere tools. As presented in the previous chapters, current approaches to the use of technology in the classroom continue to be instrumental, seeing technologies as a tool to accomplish a task, and do not address the intricacies of the effects that the presence of technology generates in the classroom (Biesta, 2016). This lack of understanding could be traced back to the confluence of a number of dominant ideas in the educational discourse, as reviewed in Chapter 1, that end up constituting a particular arrangement and configuration that is marked by “the tendency to treat knowers/knowledge as a dichotomy rather than a simultaneity” (Davis & Sumara, 2010, p. 858). Moreover, as Bennett argued (2019),

> there is a research gap on technology in education from the student’s point of view. It has been argued that the dominant academic understandings of technology and education do not privilege the voice of the learner, at best tending to speak on their behalf rather than letting them speak for themselves. (p. 45)

This research provides a contribution to the current understanding of learning with technologies by describing the nature of this socio-material entanglement and by exploring how digital technologies impact current educational practices. It does so from the perspective of the first-person account and by looking into the actor-narratives that scaffold students’ stories about learning with digital devices.

4.2.1. The Physical and Educational Context

Between the years 2014 and 2022, I was a member of staff in the college where this research took place (the secondary school where this research took place, which will be referred to as "the College" in the remainder of the thesis). One of the top-performing schools in the country, this co-educational, public school has a roll of around 2,600 students, offering a senior dual pathway of NCEA (National Certificate of Education Achievement) and CAIE (Cambridge Assessments International Education). NCEA is the national certification for secondary schools in Aotearoa New Zealand. Arguably a new certification (it was first established in the 2000s), NCEA can be seen as a creative and flexible certification pathway with the potential to credential learners for life in the 21st century (Hipkins, 2005) or just an alluring facade (Cowlishaw, 2018). Because of that, and in spite of a number of updates, some schools prefer to use alternative certifications such as CAIE or IB (International Baccalaureate), which they see as more reliable evidence of achievement (Wilson, 2019).

From the start of my tenure in the College, I was impressed not only with the high level of performance of the students across the board (in academic subjects and co-curricular activities) but also by the overt commitment that students displayed regarding school life. However, it was during a trip as leader of a co-curricular activity that my interest in researching students' relations with technology started. Together with a colleague, we had taken a group of students to participate in the *Adventure Race* in Taupo. I was staying in one of the cabins with some students when I saw one of them, hours before a 21km race, transcribing his Chemistry notes from his book into his laptop. I asked why he was doing that, and I had the most articulate answer I could hope for: His answer (which included ideas about augmentation, extension and accessibility) fascinated me both for its detail and depth. At that moment I realised I needed to somehow gather that understanding, record it and systematise it, and it became the starting point of my doctoral pursuit (although I had to wait until I left the College to start it).

This research was conducted at a momentous articulation point in time in the education discourse when the post-COVID emergency teaching (characterised by a rush towards digitalising practice) faced a “back to basics” educational agenda (where technology is being disestablished from educational contexts). Furthermore, the idea of a knowledge-rich curriculum seems to be creating antagonistic positions in relation to curriculum reform (Johnston, 2023), particularly in light of the 2018’s PISA findings in relation to the correlation between ICT use in class and the decline of literacies (OECD, 2021). Moreover, some forms of technology (mobile phones) have since been banned from schools (Ministry of Education, 2023a). In these Post-COVID/pre-curriculum reform times, the focus of education seems to be shifting back to addressing the OECD’s declining levels of literacy and numeracy (OECD, 2023a, 2023b), despite the OECD suggestions that it is maybe time to develop better strategies to enable students to effectively integrate devices into their learning in order to overcome this decline (OECD, 2023c).

In this complicated context, between the time I left the college and the time I returned to carry out my research, digital devices had been discouraged in the junior years (Year 9, 10 and 11), and discretion was recommended in the Senior School (Year 12 and 13). At the same time, the college had engaged the services of a third-party provider to communicate and emphasise the connections between handwriting and learning and memorisation. The intervention had been effective, since most of the participants, one way or another, reflected this position in the interviews. However, the use of digital devices was ubiquitous and predominant in the classrooms observed, and the contrast only filled me with more curiosity about the research.

4.2.2. NCEA and the Curriculum Refresh

The NCEA is the main school certificate in Aotearoa New Zealand. It was first introduced in 2002 at Level 1 (Year 11), and then progressively at Levels 2 (Year 12) and 3 (Year 13). NCEA is a multilevel qualification that is part of the New Zealand Qualifications and Credentials Framework (NZQCF). This framework ranges from Level 1 to Level 10 and includes certificates, diplomas, and degrees. However, underneath the NCEA certification framework sits the New Zealand Curriculum (NZC). The current full version of the NZC in use dates from 2007, and it replaces the 1992 document. Revised every few years, the NZC sets the direction for student learning for the country (Ministry of Education, 2007).

Currently, the NZC is undergoing a ‘refresh’ (Education Gazette, 2021) with the purpose of addressing underlying concerns about the “openness” of the 2007 curriculum and its lack of guidance around content choice, as well as the lack of attention to Matauranga Māori (Traditional Māori Knowledge - Wood & Aitken, 2023). At the same time, influenced by the OECD’s (2019) *Learning Compass 2030* suggestions in regard to a re-prioritisation of disciplinary knowledge, the refresh is also signalling a reconsideration of the key competencies present in what is colloquially known as the “front end of the curriculum” (TKI, 2009), which is reflected in a new emphasis on external examinations. Since not all levels of NCEA have been updated, current practice in the classroom includes both aspects of the 2007 NZC (particularly in Level 2 and Level 3) and refreshed modules (mainly in Level 1). The refreshed framework for the NZC, Te Mātaiaho, introduces an original integrative approach that calls for three elements to be integrated into all learning areas to ensure that learning is deep and meaningful (Ministry of Education, 2023). These three elements are Understand, Know, Do. This approach has a clear commitment to deep learning, which makes this new framework particularly relevant to this study. Moreover, the interconnected nature of the three elements (Understand, Know, Do) generates a cascading effect that is central to student entanglement with digital devices as will be discussed in Chapter 8.

Whilst Understand refers to the set of enduring big ideas; Know points towards the contexts that bring those ideas to life. Do, on the other hand, is oriented towards developing practices that enable learners to think and act as “experts” (Ministry of Education, 2023, p. 23). Grounded in the work of Nuthall (1999), this structure is often linked to the building of schemas. However, when Wood and Aitken (2023) argue that in this way learning becomes more than abstract understanding an accumulation of knowledge, or the development of competencies and skills, they are still insisting on elements that contribute to content schema-building (Know) or practices schema-building (Do) in order to enable a progressive and deeper understanding. This conceptualisation of progression can result, I argue, in particular forms of articulations that become extremely important for practice, particularly if there is a disconnection between socio-material practices and school, as will be discussed in Chapter 8.

4.3. The Search for the Learners' Voice

This research intends to investigate the experience of students learning with digital devices from a double perspective: the detailed analysis of the learners' singular experiences (micro phenomenology) and the socio-material analysis of that encounter (micro ethnography). The present study includes a number of classes in the Creative Arts, Design and Technology, Social Studies, Science, and English Faculties. From the literature review, it emerged that the MP approach has been conducted mainly with a reduced number of participants (Hogan et al., 2016; Sparby et al., 2021; Valenzuela-Moguillansky & Vásquez-Rosati, 2019).Therefore, it was decided to interview no more than 16 students for the semi-structured MPI interviews. Using a purposive sampling approach to ensure data representativeness (Cohen et al., 2018, p. 44), 16 students were invited to participate and 9 of them accepted the invitation to be key participants in order to explore their experiences of embodiment and cognition when learning with digital devices using micro phenomenological interviews.

The main reason for the inclusion of the ME (micro ethnography) approach was to document interactions with artefacts and ways in which they might embody concepts or entrap agencies, as a way to understand the complex relationship between people and things or, in the context of this research, between learners and their digital devices. The thick nature of the ethnographic description of practices provided an opportunity to contrast the recall of an experience with the salience that objects and artefacts might have in its constitution as well as its intertwining with social practices, since ME considers practices to be both social and material. Ethnographic research (and therefore ME too) "often grows from an observation that a material element accomplishes something important" (MacLeod et al., 2019, p. 177). This also applies to digital devices. ME documentation can take the form of (1) document and artefact analysis; 2) observation; and, 3) interviews (MacLeod et al., 2019, p. 181). Socio-materiality assumes that artefacts carry practical knowledge and are agentic (MacLeod et al., 2019), and documenting them can serve to trace affordances and entrapments (entanglements) in the construction of social practices around them. In the context of this study, the notion of socio-materiality informed the questions used in the semi-structured MPIs in order to obtain a personal description of socially observed phenomena.

4.4. Participants, Place and Ethos

Data was collected amongst senior secondary students (Year12-Year13 – aged between 16 and 18) in a decile 9 secondary school in Aotearoa New Zealand. While the researcher used to be employed at this school, employment ceased two years prior to the time of data collection. In Aotearoa New Zealand, the term decile is a socioeconomic measure used to target funding to support schools. The lower the decile, the higher the funding. Each school is given a decile rating from 1 to 10. The decile rating of a school is based on the socio-economic background of those families within the school's catchment zone. A Decile 9 school sits among the 10% of schools with the second lowest proportion of students from low socio-economic communities. This means that the school draws a significant portion of its students from relatively affluent communities. A school's decile rating, however, is not an indication of the quality of education provided at the school. From January 2023, however, the decile system has been phased out and replaced by the Equity Index. The Equity Index is a more complex and comprehensive tool to assess the socio-economic factors impacting learners. However, due to the simplicity of the decile system, I decided to use that system as an indicator.

The selection of this particular College to carry out my research had to do not only with my knowledge and understanding of its practices and ethos, or with its academic performance over the years. Both as a practitioner and as a scholar I was interested in the first-person voice and their description of students' experience. Therefore, it was (1) the high level of responsibility displayed by the students at this school in designing their own learning ecosystems, and (2) the way in which they could articulate those practices that attracted me to the location of this research. I was interested in students' accounts of how they use digital devices to achieve deep learning, such as participating in content-rich, high-stakes contexts (i.e. preparation for senior exams). All of these requirements led me naturally to work with senior learners (those in Year 11 to Year 13 of secondary school) rather than junior learners (those in Year 9 and Year 10). Based on these considerations, this study focused on senior secondary school students (Year 12 and Year 13 -between 16 and 18 years old). Students were interviewed following the observation of a learning event involving digital devices. The learning event was not designed by me but was a standard lesson designed by their subject teacher (see Table 7 for the full list of subjects involved) in which students were required to use devices to accomplish their learning. The lessons were video-recorded. Sixteen students were invited to participate in an MPI of about 60 minutes afterwards (which was also video-recorded). Nine of the invitees accepted the invitation. Table 6 below provides relevant background information on the participants and lists the device they used. G1 and G2 are coded identifiers used to describe their declared gender in the school SMS. The same applies to E1 to E5, used as coded identifiers for their preferred ethnicities. Demographic background information was not used as a variable during analysis. The information is presented here only as examples of purposive sampling. Table 2 below shows the details of demographic background information. Students would be referred as “they” to preserve gender neutrality.

Table 2

Key participant distribution according to year level, gender, ethnicity, and type of device used.

Participant	Year Level	Gender	Ethnicity	Type of Device
Student 1	13	G1	E1	laptop
Student 2	12	G2	E2	laptop/graphic tablet
Student 3	13	G1	E3	tablet
Student 4	13	G2	E3	iPad
Student 5	13	G2	E2	laptop
Student 6	13	G1	E5	laptop/digital camera/scanner
Student 7	13	G1	E2	laptop
Student 8	12	G1	E1	laptop

Student 9	13	G1	E4	laptop

4.4.1. Timeline and Distribution of Participants

The study included a number of classes where students learned with digital devices. A lesson in each of these classes was observed and recorded. After the observations, students were sent a Digital Survey and those who indicated interest and/or were identified in the observation notes as possible candidates were interviewed using a semi-structured MPI interview format (Petitmengin, 2019). The approximate duration for each interview was 30-50 minutes. The interviews took place during the third term of 2022 (22 Jul – 30 Oct). Table 3 shows the list of lessons observed, the volunteer teacher in charge of that class, and the number of students.

Table 3

List of lessons observed.

Subject	Teacher	# of students
Y13 Science	Teacher 1	32
Y13 Photography	Teacher 2	31
Y12 Art and Design	Teacher 3	18
Y13 Art and Design	Teacher 3	29
Y13 English	Teacher 4	25
Y12 Media Studies	Teacher 5	21
Y12 History	Teacher 6	26

Up to 16 students were selected for a short follow-up interview. Purposive sampling was used to select students for the follow-up interviews. The selection was done to ensure that the interviewed students 1) had used a device in the observed class; 2) represent a variety of digital skill levels; 3) used a variety of digital devices; 4) represent the full scope of observed lessons; and 5) represent a variety of modes of engagement. Students not using digital devices were not included, since the focus of the study was on digital engagement. Students who were at some point of their school life taught by me were also excluded since it could have constituted a conflict of interest or at least cloud the reliability of the answers. Table 4 shows the number of participants invited to participate in the MPI and the subject area of the lesson they attended. A green box indicates that they became key participants. A yellow box indicates they were invited to become so, but they declined.

Table 4

Students invited to take part in the MPI. Green shows the students who became key participants.

Class	Student 1	Student 2	Student 3
13 Art and Design			
13 English			
12 Art and Design			
13 Photography			
12 Media Studies			
13 Science			
12 History			

Using a purposive sampling approach in order to achieve maximum data representativeness (Cohen et al., 2018), 16 out of the 54 respondents to the digital survey were invited as key participants to participate in a MPI. Only 9 of those 16 accepted the invitation. To ensure maximum data availability, the interviews were organised in two sections. In the first section of the interview, students were asked to recall the learning experience that was recorded as part of the class observation. In the second part of the interview, they were asked to evoke a chosen experience where the use of a digital device for learning was important for them (in class or outside school). Table 5 shows the list of key participants and their experiences.

Table 5

Key participants.

Participant	Main experience (recorded)	Chosen experience (only evoked)
Student 1	Handwriting versus digital	Coding syntax support
Student 2	Memory and writing	Drafting on paper or digital
Student 3	Note taking processes	N/A
Student 4	Typing versus writing	Using notebook for note taking
Student 5	Drawing using a pad	Digital zooming and focusing
Student 6	Physical versus digital creation	From plan to essay
Student 7	Using Arc (Internet browser)	Mimicking platform features
Student 8	Summarising with AI	Digital annotation of texts
Student 9	Creative process cycle	Digital submissions

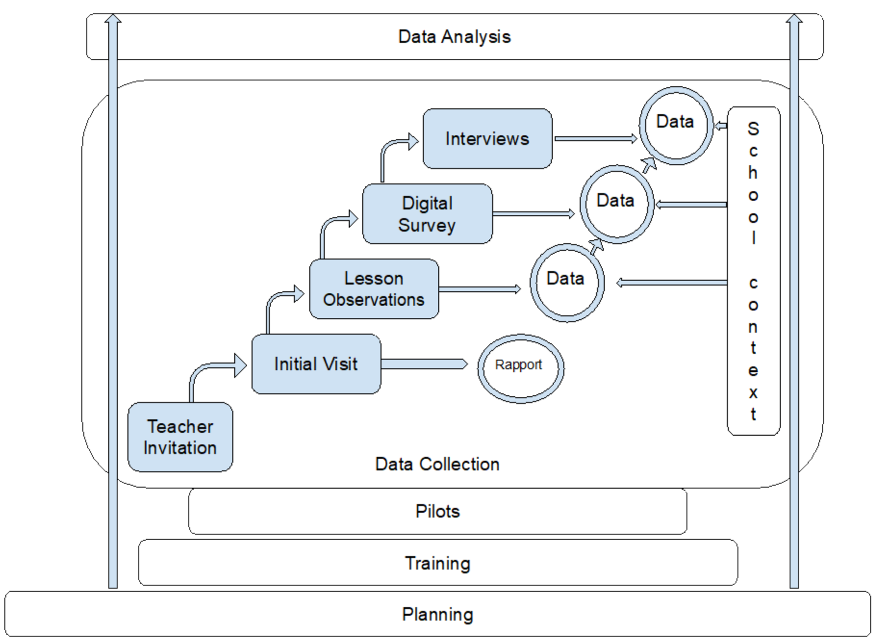
The next section presents in more detail the different aspects relating to the selection of participants and overall aspects of the logistical design of the study as well as accounts of any changes implemented in response to specific challenges encountered on the way.

4.5. Study Phases, Preparation, and Piloting

This study was organised into five phases: (1) planning; (2) training; (3) pilots; (4) data collection, and (5) analysis. Figure 6 shows the organisation of these phases.

Figure 6

Study phases and data collection process.



Planning

As mentioned in Chapter 1, this research emerges both from a scholarly and a practice inquiry. Although from an early stage, I was set on the wider focus of the study (the role of technology in the classroom), it took the best part of a year to revise the existing literature in order to corroborate that the knowledge gap identified as a practitioner was also present in the literature. Therefore, the planning stage included

1. An investigation of the existing academic literature
2. The refinement of the research question(s)
3. The identification of suitable methodologies
4. The identification of a suitable study site

During the planning stage, the scope of the study was confirmed to be the digital phenomena. It was at this point that it was decided not to conduct a comparative study involving a control group that does not use digital devices. Based on these decisions, the research questions were refined a number of times, and considerable work was put into identifying suitable methodologies to study phenomena from the perspective of the learners as well as paying attention to the socio-material practices around digital learning. As presented in Section 2.7, micro phenomenology and micro ethnography were identified as complementary methodologies to study the chosen phenomenon from the double perspective of the first-person voice and the socio-material dynamics. However, another important question to consider was the site of the research. One of the limitations of micro phenomenology is the reduced number of key participants. Since one of the main foci was to capture the first-person voice, it was important to select a location where a maximum of data could be collected from a limited number of interviews. The decision to confirm the selected site was informed by my previous interactions with a number of highly articulate students during my years at the College.

Methodological Training

Once it was confirmed that micro phenomenology and micro ethnography were the approaches best suited for the study, I undertook training in both methodologies. A key feature that these methodologies share is that their unit of analysis is the stories that participants recount from their experiences. For both of these methodologies, interviews are common means for capturing these stories. Micro phenomenology, in particular, relies on the use of micro phenomenological interviews (MPI), which will be described in more depth in the following sections. Through the micro phenomenology website (https://www.microphenomenology.com/home), I came across Camila Valenzuela, and took part in one of her MPI and MP analysis courses. The MP training consisted of 180 hours over four modules, including individual, group, and supervised work, which I completed remotely (since the course was based in South America) from April to November 2022. Concerning micro ethnography, I sought advice from Dor Abrahamson, chair of the Embodied Design Research Laboratory at UC Berkeley (EDRL https://edrl.berkeley.edu/).

EDRL is a design-based research laboratory that focuses on mathematical cognition and instruction. EDRL uses micro ethnography to research cognition by applying Microgenetic Learning Analysis (Parnafes & diSessa, 2013). A number of trial and errors led me to another type of micro ethnography, in the format of narrative analysis.

Pilots

In order to build confidence in relation to the methodological approach, I ran two pilots. The first one was designed to test the efficacy of the selected methodologies for the study of cognitive processes facilitated by digital devices. The second one was designed to test the use of MPI on secondary school students (since this kind of interview requires a high level of introspection which, in my experience as an educator, can sometimes be challenging for teenagers). The results from both were positive. The first pilot used MP to look into problem-solving strategies when completing the online puzzle Wordle (https://www.nytimes.com/games/wordle/index.html). For the second pilot, three students were interviewed using MPI. The method proved efficient at eliciting information on the students' experiences and provided me with some essential skills to redirect the interviews towards a single experience.

Data Collection

While data collection and sampling have been discussed in detail in Chapter 3, Section 3.5.1, the current section describes the logistical aspects relating to the data collection. In the following, I describe the process in the following sections with reference to the visual representation flow presented in Figure 6 above.

Teacher Invitation

The first point of contact with the school was with the principal to request permission to access the College. Once permission was granted, using information publicly available on the College's website, I contacted several heads of faculty and heads of learning by email, inviting them to participate in the research. Table 6 lists the faculties contacted. The highlighting indicates those who replied to the invitation. One extra teacher volunteered when I visited the college for the first time.

Table 6

Invited teachers and their subject areas.

Subject Area	Name
Commerce	Invitee 1
English	Invitee 2
Science	Invitee 3
Social Sciences	Invitee 4
Art	Invitee 5
Biology	Invitee 6
Business Studies	Invitee 7
Chemistry	Invitee 8
Classical Studies TIC	Invitee 9
Computer Science and Digital Technologies	Invitee 10
Director of eLearning	Invitee 11
eLearning Assistant	Invitee 12
Geography	Invitee 13
History	Invitee 14
Languages	Invitee 15
Media Studies	Invitee 16
Music Curriculum	Invitee 17

Physics	Invitee 18
Teaching & Learning	Invitee 19
Trades and Technology	Invitee 20

Note. A yellow box indicates that they replied to the invitation.

The role of the teachers in the study was limited to granting me access to their classes. I did not interfere in any way or form with the teachers' planning or delivery of the classes. The only requisite for their participation was that in the lesson I observed, students were required or allowed to use their digital devices. There were no requirements in relation to what devices or to what purpose. My intention was to observe students' usage of devices in as much of a natural setting as possible. Relevant here is also that the college is BYOD (Bring Your Own Device) so devices are owned and managed by their users (other than the enforced Firewall and Safe User Agreement policies limitations expected from an educational organisation) rather than the school.

Initial visit

Once the volunteer teachers signed their Teacher Consent Form (see Appendix B section f), I visited the classes to (1) introduce myself; (2) showcase a brief demonstration of what an MPI looks like; and (3) recruit student volunteers. The first school visit was on March 10th 2023. I used that time not only to build rapport with the participants, but also to assess the logistics of video recordings in each room (camera positioning and the creation of safe spaces for non-participants. Students' Information Sheets were distributed digitally and in print.

Lesson observations

The second school visit took place between the 27th and 31st of March 2023. After confirming that all students had either signed the Participation Consent Form and the Consent and Release form or sat outside of the camera scope, all lessons were observed and recorded for the full length (60 minutes). The equipment was in place before the students walked into the class. Table 7 shows a detail of the observed lessons. It includes: (1) the teacher in charge of the class; (2) the subject of the class; (3) the number of students in the class; (4) if the lesson was video-recorded; (5) the number of student from that class that responded to the digital survey after the observation; (6) if there was a GORP observation; (7) if observation notes were taken; (8) how many key participants were identified; and (9) the number of key participants that accepted the invitation in that class.

Table 7

Lesson observation list and student respondents to the digital survey and the GORP record.

Teacher	Subject	# of students	Video Recording	Digital Survey Response	GORP	Notes	# Key Participant Invitation	# MPI
Teacher 1	Science	32	Y	0	Y	Y	3	3
Teacher 2	Photography	31	Y	15	Y	Y	1	1
Teacher 3	Art and Design	18	Y	5	Y	Y	2	1
Teacher 3	Art and Design	29	Y	10	Y	Y	3	2
Teacher 4	English	25	Y	3	Y	Y	3	1
Teacher 5	Media Studies	21	Y	5	N	Y	1	0
Teacher 6	History	26	Y	15	N	Y	2	1

Digital Survey

The Digital Survey was circulated as a Google Form. Teacher participants were requested to post it on their Google Classroom. The response was optional, and students received one reminder. Teacher 1 forgot to post it so the key candidates were contacted directly via the email provided in the Consent Form to invite them to take part in the MPI. The survey contained 7 questions. Three of the questions focused on identifying the learners willing to be contacted and to identify their classes. The remaining four questions were designed to ascertain (1) how important the use of their devices was to assist their learning; (2) in what ways their device assisted their learning; and (3) to describe the type of digital device(s) they were using (iPad, laptop, etc.).

Interviews

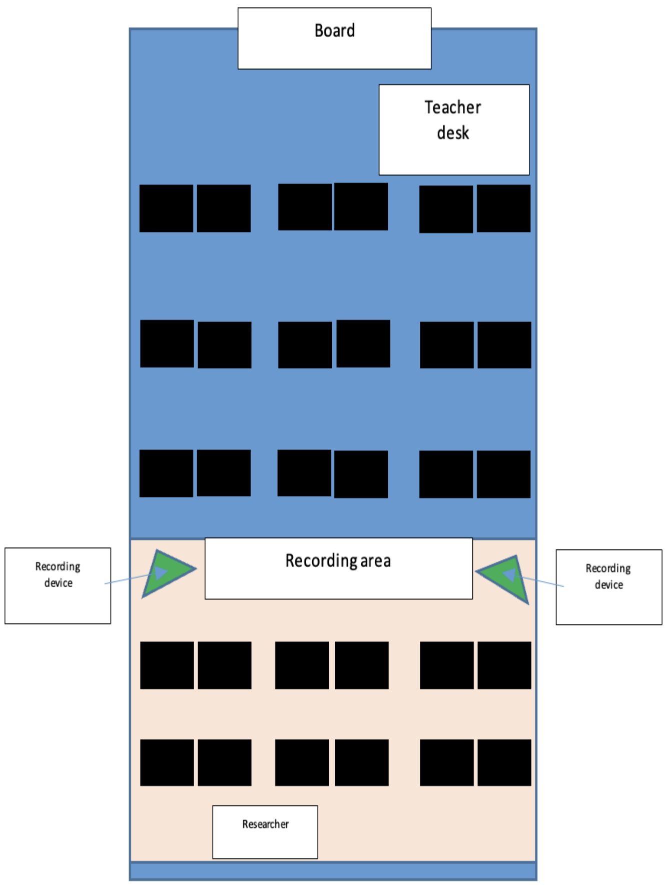
Interviews constituted the central data collection tool of this study. They were the basis for both the micro phenomenological and micro ethnographic analysis. The interviews took place on the 30th and 31st of March 2023. They were conducted in one of the meeting rooms of the College where the research took place to minimise student disruption and to ensure participants were in a familiar environment and felt at ease. Although the MPI had been piloted in advance, the application of the method to this particular context was not without its challenges. These challenges are discussed in Section 4.5.2. The MPIs were designed to maximise the gathering of data. To do so, the interview focused on two moments. The first section of the interview focused on the students' recorded lesson. The second part of the interview requested the students to evoke a learning event (either at school or in any other context) where the use of digital devices was important.

Video Recording Protocol

Both micro phenomenology and micro ethnography require video recordings to capture the full extension of the experience. Therefore, both class observations and MPIs were video recorded. Special attention was paid to ensure that only those students who had signed the Consent and Release form (see Appendix B section f) were recorded. Hall (2007) recommended the use of two cameras to record the interactions, one directed towards the student(s) and another towards the teacher. As a way to minimise interference, clear picture and sound, and not zooming or panning is advised (Erickson, 1992). Figure 7 shows a plan of the recording setup in the classroom, and the full observation protocols are presented in Appendix B section b. A single camera trained on the interviewee was used for the MPI as a way to minimise the possible intimidation produced by these devices.

Figure 7

Recording protocol for the lesson observation.



Note. The blue section represents the area outside of the cameras scope for non-participants.

Data Analysis

Detailed information about the process of data analysis has already been presented in Chapter 3: Methodology, including how data was analysed in each of the methodologies, and how a diffractive theoretical lens was used to bring both sets of findings into a dialogue. This chapter, therefore, only features a description of the logistics involved in the data analysis. One of the issues encountered related to the processing of the interview transcriptions. Since MPI focuses on the unfolding description of a single experience, there is a type of information present in the interviews that is used, but also another type that is discarded, such as descriptions of general experiences, induced statements, and satellite information (Valenzuela-Moguillansky & Vasquez-Rosati, 2021, p. 126). Thus, one of the first steps of the micro phenomenological analysis was refining the data (Valenzuela-Moguillansky & Vasquez-Rosati, 2021). This process involved identifying the information that would not be part of the analysis. “Satellite information includes the description of the context in which a certain experience takes place, the description of theoretical knowledge, as well as the beliefs or judgments that we may have in relation to what has been narrated” (Valenzuela-Moguillansky & Vasquez-Rosati, 2021, p. 126). However, although satellite information was not included in the final analysis, it is recommended that this information is kept as an indicator of the quality of the evocation and to signal temporal aspects of the description (Valenzuela-Moguillansky & Vasquez-Rosati, 2021).

The focus of this research is not only the exploration of the experience of learning with digital devices but also the first-person perspective of that experience. Therefore, although satellite information was excluded from the MP analysis, it was not only kept but included in the micro ethnographic analysis since it offered an authentic opportunity to delve into the learners' perceptions, opinions, and explanations of phenomena. However, and most importantly, it reflected a know-how and, therefore, a way to bridge the testimonial and hermeneutical epistemic injustice (Flicker, 2007) that was observed as part of the gap in the literature relating to the absent voice of the learners in educational research regarding technologies in the classroom (see Chapter 2). Table 8 presents a selection of the main thematic blocks of satellite information identified.

Table 8

Sample of blocks of satellite information identified in the verbatims.

Participant	Main experience (recorded)	Chosen experience (only evoked)
Student 1	Handwriting versus digital	Coding syntax support
Student 2	Memory and writing	Drafting on paper or digital

Student 3	Note taking processes	N/A
Student 4	Typing versus writing	Using notebook for note taking
Student 5	Drawing using a pad	Digital zooming and focusing
Student 6	Physical versus digital creation	From plan to essay
Student 7	Using Arc	Mimicking platform features
Student 8	Summarising with AI	Digital annotation of texts
Student 9	Creative process cycle	Digital submissions

The data analysis worked as a two-tiered system of abstraction. After completing both the micro phenomenological and micro ethnographic analyses, I recognised that further interpretation was necessary. Only through thorough examination of the collected data could I determine how to meaningfully connect my findings with existing scholarly discourse. However, this process was reciprocal: engaging with established literature not only contextualised my research but also transformed the data collected, giving it a theoretical format in which it could enter into conversation with other theories to produce a new set of findings (see Chapter 5, 6, and 7).

4.6. Challenges and Approaches

The micro phenomenological analysis used in this study is based on the process proposed by Valenzuela-Moguillansky and Vásquez-Rosati (2019). However, due to a variety of factors encountered as part of the data collection process, a number of changes to their process had to be implemented to account for the specific context of this study. The reasons for the adjustment and the nature of the changes are discussed in this section.

4.6.1. Hallmarks/Invariants

The micro phenomenological method was initially created to offer a description of a single experience (Vermersch, 1994). However, micro phenomenology can also be used to identify the structure of multiple experiences via the analytical, iterative unfolding and refinement of structures (Petitmengin et al., 2018). These generic structures are often referred to as "invariants" (Petitmengin, 2006; Petitmengin et al, 2018; Valenzuela-Moguillansky & Vasquez-Rosati, 2021). However, "Husserl's Phenomenology and micro phenomenology differ in the process of identification of this structure" (Petitmengin et al., 2018, p. 692). Whilst Husserl's eidetic variation (imagining an object of the kind under investigation and varying its features) works at a level of possible rather than actual facts, micro phenomenology "highlight invariants from singular actual facts" (Petitmengin et al., 2018, p. 692).

Despite this well-documented and agreed-upon language in the field of micro phenomenology, I prefer to use the term "hallmark" (Luecke, 2023) rather than invariant or structure, since this term signals more a set of distinguishing features rather than a collection of permanent ones, giving the notion more dynamism than the traditional reference to structural invariants. Also, by committing to this term, I focus on a typical characteristic or feature of the experience rather than insisting on an invariant structural quality, thus highlighting the dynamic nature of the experience. At the same time, the term hallmark refers to distinctive features of the experience rather than a constitutive part and therefore allows for structural variations without affecting the validity of the hallmark. Within the context of the current study, the term hallmarks refers to the common attributes or similarities amongst the experiences. That is to say, it is a descriptive tool and not a conceptual one.

4.6.2. Adaptations, Negotiations, and Inventions

A number of methodological adaptations had to be applied in order to carry out this research. In the first place, working with secondary-school-age students required particular attention to the process of MPI from a number of perspectives. During the pilot stage of this research, it was obvious that some interviewees adapted their recounts to fit with what they perceived to be the researcher's focus or perspective (what was "wanted from them"). This required including both very explicit statements in regard to the focus on the first-person point of view and clarifications in regard to the focus of the research (how and if rather than the effectiveness of digital devices in the classroom). Another aspect that needed consideration was gathering sufficient data from the recall of a single experience. To ensure a thickness of data, the MPIs were organised in two sections: a first recount based on the recorded observation followed by an account of a significant learning experience with devices (at school or otherwise). Each experience was addressed independently. For the analysis, the evocation of the experience recorded in class was privileged (except when there was no density of data (Student 8) or if the chosen experience was somehow exceptional (as in the case of Student 4 and their ability to 'zoom-in' in their memories).

Another aspect constitutive to the MPI is the "cleaning up" of the spoken language, focusing the analysis on the statements directed towards the description of the target experience, and treating all other information as satellite. From very early on, it was clear that the data present in the satellite information was important to fully understand the core statements and the description of the experience. Rather than discarding them as general satellite information, they were considered micro-experiences. Although they were excluded from the main MP analysis, they were signposted on the transcripts as autonomous units and as valid and reliable sources of information (a micro-MPI of sorts). These micro experiences were found to contain important elements of the first-person voice (such as consideration, know-how, valuations, and preferences). Therefore, these micro experiences were not excluded from the micro ethnographic analysis. For the micro ethnographic analysis, the verbatims were treated as a collection of micro-MPIs and analysed in their totality.

Finally, Valenzuela-Moguillansky and Vasquez-Rosati (2019) advised identifying semantic networks to identify how different structural aspects of the experience relate to each other. To preserve the synchronic hallmark of the experience as the hinge where the two methodologies (micro phenomenology and micro ethnography) interact, the process of abstraction and identification of the synchronic hallmarks was done not via micro phenomenological synchronic analysis, but via micro ethnographic narrative thematic analysis. Instead of using Valenzuela-Moguillansky and Vasquez-Rosati (2019) Semantic Networks or Dynamic Lines, I applied Thematic Dynamic Lines to create a dialogue, not only between the diachronic and synchronic qualities of the experiences, but also between the two methodologies used for this study, thereby offering, to the best of my understanding, a methodological innovation in the field of micro phenomenology.

4.7. Macro and Micro Perspectives

As I embarked on this project, one of my main concerns was to honour the voice of the participants by not only capturing the voices of participants but also paying particular attention to representing their views and experiences in as true a form as possible (Mauthner, 2002). As Braun and Clarke (2022) pointed out,

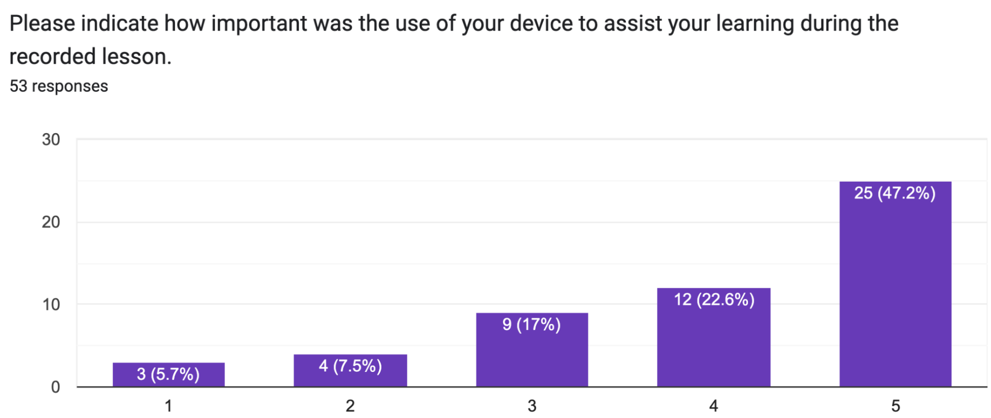
> researcher subjectivity is the primary tool for reflexive [thematic analysis], as knowledge generation is inherently subjective and situated. [The researcher's] subjectivity is not a problem to be managed or controlled, to be gotten rid of, but should be understood and treated as a resource for doing analysis. (p. 9)

The interpretation of data, they continue, cannot be objective, but can be weak. They understand themes as analytic outputs developed from codes which, although underpinned by theoretical understandings, cannot be identified before the analytic process. Therefore, I had to keep my own bias in check (Onwuegbuzie & Leech, 2007) when it came to references to the digital (the main focus of my research).

An interesting point to note here is a puzzling contradiction in the dynamic of digital/analogue learning preferences observed amongst the students. After the initial observation and recording, students were sent a basic online survey in the form of a Google Form. One of the questions asked the students: "Please indicate how important was the use of your device to assist your learning during the recorded lesson", (1 being not very important and 5 very important). As shown in Figure 8, over 47% indicated that it was very important, and close to 70% of the respondents chose option 4 or 5.

Figure 8

Respondent responses.



Note. Respondent responses to the question "Please indicate how important was the use of your device to assist your learning during the recorded lesson", (1 being not very important and 5 very important).

Despite having used devices in particularly interesting ways in class, several key participants would come into the interview overtly defending their preference for analogue learning. This dynamic confirmed the appropriateness of the initial decision to use a mix of micro phenomenology and micro ethnography, since there seemed to be some sort of disconnect between participants' first-person narratives and their socio-material engagements. All of the key participants have demonstrated high levels of entanglement with their digital devices in the process of constructing their cognitive artefacts. The micro phenomenological analysis provided tools to understand what the process of coming in contact with their digital devices looked like from the perspective of the first-person. However, particular attention had to be paid to the construction of the themes emerging from the narrative analysis whilst keeping intact the voice of the first person, even if it was articulated as a contradiction. Ethnography offers the researcher a unique opportunity to look both into verbal and artefact interaction (Asare, 2015).

This research positions itself in both the micro phenomenological and the micro ethnographic camps as an intersecting diffraction. As such, some of the foundational ideas of micro phenomenology in regard to individuals not being fully aware of all the dimensionality of their experience (Petitmengin, 2017), came into play in the micro ethnographic analysis, as the actor-narratives (Frank, 2010) became co-constructed from the students' storytelling and their material engagement. The findings of this research, although organised in chapters that align with the methodologies from which they arise (Chapter 5 and 6 from micro ethnography, and Chapter 7 from micro phenomenology), cannot be understood independently. Donna Haraway (1997, 2004) and Karen Barad (2007, 2014) have referenced the diffraction framework as a relational framework. In the same line, the two approaches presented in this study are diffractively read through one another. As Barad (2014, p. 168) pointed out,

> diffraction is not a set pattern, but rather an iterative (re)configuring of patterns of differentiating-entangling. As such, there is no moving beyond, no leaving the 'old' behind. There is no absolute boundary between here-now and there-then. There is nothing that is new; there is nothing that is not new. (p. 168)

What I propose here, therefore, is to describe phenomena from the intersection of the analysis of the first-person recount of the experience and the narratives that scaffold their stories. Although this can be at first sight a contradiction, diffraction offers a fertile lens to bring both methodologies into a dialogue.

4.8. Summary

This chapter expanded on Chapter 2's discussion of micro phenomenology and micro ethnography, and Chapter 3's description of the methodology by introducing a more personal narrative in relation to the selection of these methodologies. It also explored the personal history of the researcher in relation to the values and beliefs of the college, as well as the current complexity of the educational discourse and the presence of technologies in the classroom in a re-accommodating period after the Global Pandemic of 2020. Finally, after describing the location, participants, and ethos of the research, the chapter discussed the challenges encountered and the resulting methodological adaptations and inventions that were required in the application of the methodologies, as well as how these changes espouse the general philosophical articulation of this thesis.

Chapter 5. Thinking (with Technology): A Tale of Two Selves

5.1. Introduction

The findings of this study are presented in three separate chapters. These chapters present the findings of the two approaches used to analyse the data: micro ethnography (ME) for Chapter 5 and 6; and micro phenomenology (MP) for Chapter 7.

The present chapter, Chapter 5, introduces the thematic analysis, starting with the overall structure of the themes. Chapter 1: Introduction presented the foundational metaphor of the present study, The Tale of Two Schools, which is further developed in the present chapter by introducing a complementary metaphor: The Tale of Two Selves. The Tale of Two Selves is a way to understand the dynamic of the main themes of thematic analysis. This metaphor explores the tensions emerging through system constraints and subsequent negotiations undertaken by students can lead to hinging resolution between two possible identities. Next, after tracing Vial's (2019) eleven characteristics of the digital on the students' accounts, I propose an extension of his ontophanic approach by reading my findings through Stalder's (2018) Digital Condition. I suggest a revised definition of the digital as a structure of perception and action by presenting a tentative list of criteria to define digital artefacts.

5.2. A Tale of Two Selves

This section is an introductory look at the ME findings. After a number of iterations of coding, reviewing, and redefining, a general structure of the themes emerged from the data (see Appendix C section f for a full list of themes). Continuing with the foundational metaphor of this thesis (A Tale of Two Schools), in this chapter, I introduce an extension of the same idea, the Tale of Two Selves, as a way to help make sense and explain the dynamic of the system of themes and subthemes emerging from the ME analysis.

The Tale of Two Selves framework centres on a fundamental tension that emerged from the data: whilst students frequently expressed preferences for analogue approaches and acknowledged institutional messages about the importance of traditional learning practices, their actual engagement with learning tasks revealed a markedly different pattern of behaviour. This disconnect between declared preferences and observed practices suggested the presence of two performatively accomplished identities that students navigate when confronting learning challenges. To validate this assumption empirically, I administered a digital survey to the observed students immediately following classroom observations. 53 of those responded to the survey. The survey findings, presented in the following section, evidence the existence of this tension in students' everyday learning practices.

The following sections will first describe the coding process and the identification of the emerging narrative, before contrasting it to the survey findings, which demonstrate the tension that drives the analytical framework presented in this chapter.

5.2.1.The Coding Process: An Emerging Narrative

The thematic analysis of the data followed the stages suggested by Brown and Clarke (2022). One of the main aspects of this methodology is its reflexivity. In order to build that reflexivity the thematic analysis was highly iterative, moving from Braun and Clarke's (2022) stage (2) to (5) (see Section 3.5.2 for details). Appendix C section e features an example of the coding process. This iterative process was applied to both approaches, since both methodological analyses were undertaken simultaneously rather than consecutively. This reflexivity also included an ongoing critical evaluation of my own biases to ensure that conclusions were drawn from the data rather than being led by my own assumptions.

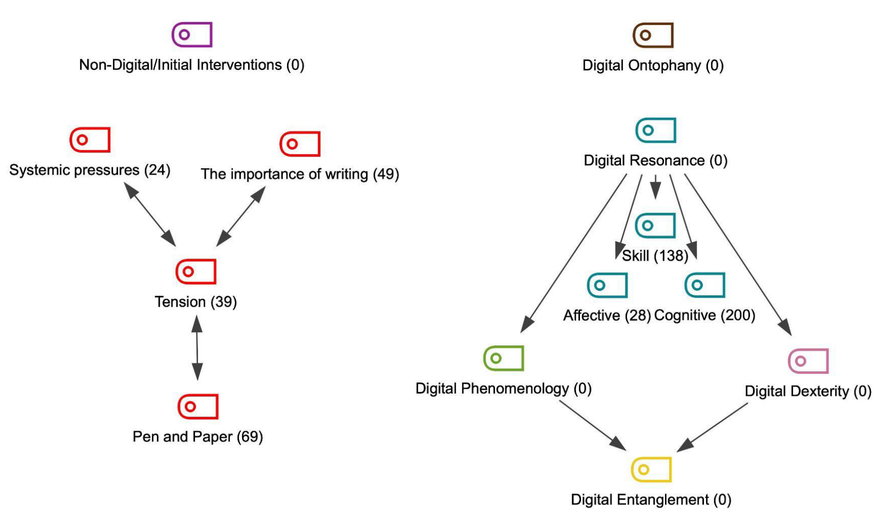
The initial familiarisation phase was influenced not only by the theoretical underpinnings guiding the research (as presented in Chapter 2), but also the early stages of the study (the pilots). During one of the pilots, an incipient structure of two fuzzy moments or stages started to emerge in the participants interviews: an initial solo (or analogue) drafting and an assisted (or digital) crafting. This trend reappeared during the study, and it constituted one of the first levels of coding. A second familiarisation cycle included the identification of Vial's (2018, 2019) characteristics for the digital. Although the author of these characteristics of the digital did not intend for them to be used as an analytical tool, I traced them in the students' interviews as a form of reflexivity. In doing so, I questioned my own theoretical approach, by corroborating that the students' characterisations of their experiences with digital devices suggested some form of digital structuration of their perception (in the form of Vial's characteristics). The presence of

Vial's (2019) characteristics in the data became the first Digital theme to surface. Successive interactions saw the emergence of the family of Digital themes (Digital Resonance; Digital Phenomenology; Digital Dexterity, and Digital Entanglement).

Therefore, Drafting vs Crafting and Digital Ontophany become the two initial fuzzy group of ideas under which the coding sequentially and iteratively evolved. This led to the construction of two main umbrella themes —which were used to progressively organise the coding process: Digital Ontophany and Non-Digital. The Digital Ontophany theme collected all the coding relating to students perceptions in regard to the digital (which will eventually become Digital Resonance; Digital Phenomenology; Digital Dexterity, and Digital Entanglement), The Non-Digital theme collected students interventions (strategies, actions, practices, beliefs, etc.) that indicated some sort of movement between Drafting and Crafting, but were analogue (or at least non-digital; such as revising, copying, transcribing, etc.). In early iterations of the thematic analysis, the Non-Digital theme was set aside (to be discarded), since the Digital was confirmed to be the focus of this research. However, applying critical reflexivity, I realised that discarding them would have meant disregarding an important aspect of the stories presented by the students. Figure 9 shows the initial coding structure. In this structure, themes are arranged hierarchically as a network of interrelations, as indicated by the arrows. These interrelations are explored and developed in detail throughout the present chapter. The number in brackets indicates the number of times the code was applied across all interviews. If the number displayed is (0) it indicates that this is a Theme (and not a code or subcodes).

Figure 9

Initial organisation of themes and codes.



Since one of the initial methodological decisions was to make the digital the focus of this study (see Section 4.4), it would have made sense to only progress my analysis of the Digital Ontophany theme. However, it was only when I looked at both Digital Ontophany and Non-Digital themes together that I realised that in this dichotomy presented (and was articulated by) a tension, that needed to be discussed too. The Non-Digital theme includes two sub-themes, which highlighted some sort of constraint in relation to adopting digital strategies: Systemic Pressures and The importance of Writing. I initially coded these only to understand the different aspects of the experience, on the belief that they were to be discarded. However, after a holistic understanding of the process (also informed by the MP findings), it was obvious that the resolution of them created a tension (coded as Tension), that played an important part in relation to learning with digital devices or not: accepting the System Pressures as heuristics (or its rejection) seemed to be informing the direction in which the articulation of this dichotomy would be resolved. It is at that point that the metaphor of the Two Selves was born.

Thus, tension emerged as the property that seemed to connect two distinct sets of strategy (analogue and digital). Analogue aspects mostly referred to ideas associated with traditional good practice, while digital aspects were associated with novel practices or perspectives built through their own digital devices' usage. For example, Student 7 referred to this tension when stating that, although they would like to take notes digitally, they used pen and paper because of a school policy:

> I don't do that personally because my school actually made a commitment to getting people back to writing in books, because there have been scientific studies that have proven that [it] allows you to remember better. (Student 7, 298[2])

Similarly, Student 8 expressed that they would refrain from making online annotations because "our teacher recommended to us that it will be very tiresome or tedious for the marker to go back [and read them]" (Student 8, 108), leading to the possibility of being penalised by the markers.

[2] The number following the Student identifier corresponds to the line/paragraph number allocated to the transcription in MAXQDA. It does not have analytical purpose but serves as a tool of data verification.

At the same time, other participants indicated that there were some Systemic Pressures pushing them towards the digital too, as illustrated by Student 6, who, referring to the generalised use of Google Classroom across his classes, said that “it just almost turns into a habit. So, I'm going into my class and every day I'm opening up my laptop, so it begins to become something that happens almost like autonomously” (Student 6, 77).

These Systemic Pressures, eventually, could turn into Tension between what they preferred to do versus what they should be doing, as illustrated by Student 7, who commented that they preferred digital note taking despite their school’s commitment to handwriting:

> I would definitely like to take my notes on my devices, because I feel like I'm a lot more proficient with doing that. Just because outside a few diagrams and a few tables here and there, I can make my notes a lot clearer on my device. (Student 7, 298)

Student 6 also experienced this tension when they said that, in spite of their preference for analogue work, they conceded: “I use digital photography because it's just more versatile and ethically better”. However, participants suffered consequences for using digital strategies, as illustrated by Student 8, who recounted: “I did do it digitally [annotating a text] but it wasn't very helpful for the marker so I got downgraded a bit for that” (Student 8, 111).

An interesting aspect relating to these two sets of strategies used to bridge the tension is the fact that most participants would come into the room indicating, for example, their preference for analogue approaches and the importance of handwriting over digital. However, all of the key participants were identified as salient users of digital devices. It is in this disconnect that the idea of the Two Selves is anchored. It seemed that all the messages about what it meant to be a “good student” were pulling them in one direction, whilst practical aspects of their own learning or practice were pulling them in the opposite. The kinds of statements included in the Tension theme highlighted that behind the students' comments there was a collision between different systems of values, beliefs, and perceptions; systems in which the students constructed different versions of themselves to direct the resolution of this (socio-material) conflict or tension. Sitting outside the scope of this research, there is a rich body of literature exploring how different phenomena are accomplished or performed in interactional socio-material contexts. That is to say, certain aspects of the human experience are not merely fixed or inherent characteristics but are dynamically shaped and expressed through social interactions and within the specific material and environmental conditions in which those interactions occur. Some examples of such performatively accomplished phenomena can include age (Phoenix & Sparks, 2008), gender (Butler, 2002), selfhood and identity (Murray, 2003), and life course in general (Laz, 1998).

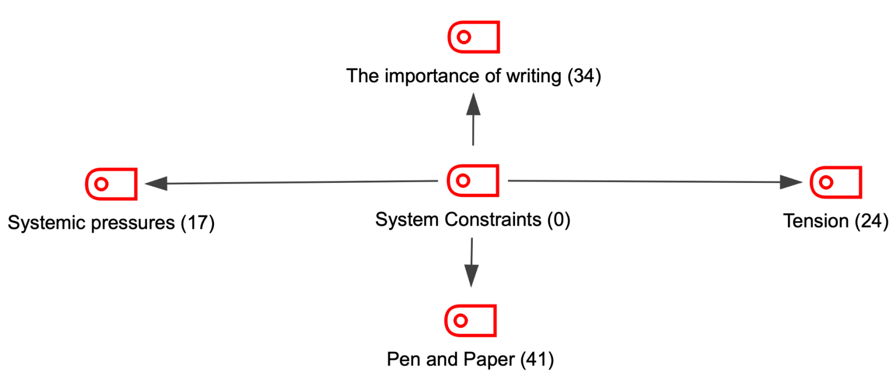
In Section 2.7, I presented the role of the stories as ways to make sense of experience. However, in the light of this performative accomplishment, the argument could be pushed further. People "construct identities (however multiple and changing) by locating themselves within a repertoire of emplotted stories" (Somers, 1994, p. 614) that provide a framework through which they make sense of their experiences and define who they are. That is to say, in time, these stories guide action in "certain ways, and not others" (Somers, 1994, p. 614). The Tale of Two Schools (the tale of the clashing of paradigms in the battlefield of the classroom, presented in Chapter 1), in turn becomes the Tale of Two Selves, where students' identities are performatively accomplished according to the modes of resolution selected for this tension. This resolution is an entangled negotiation in which the accomplishment of maximal grip on the task —understood as positioning oneself to perceive and interact with the world in the most optimal possible way (Dreyfus, 2014; Merleau-Ponty, 1962)— becomes paramount.

5.2.2. Two Selves: Tension as the Axiological Battleground

The previous section, through the description of the coding process, presented the emergence of both a narrative, and the main themes of the thematic analysis. This section presents the dynamic of the Two Selves metaphor through a description of some of the main themes. Figure 10 present the final structure of the System Constraints theme.

Figure 10

Hierarchical code and subcode model of the theme System Constraints.



The first thing I noticed in the data was that the selection of stories evoked by the student participants in relation to their learning experiences with digital devices implied some sort of immanent stages: a) a manual draft stage; b) an initial unassisted performance; and c) a final (digitally) assisted resolution of the task. At first, these stages were denominated: 1) drafting; 2) exploration; and 3) crafting. However, it became obvious that there were more levels of analysis than those three. As mentioned in the previous section, two of the first thematic organisations used were: a) a distinction between Digital and Non-Digital narratives; and, b) a fuzzy conflation between an institutional voice and the learners' stories.

System Constraints became the theme containing the initial codes under the Non-Digital umbrella (Figure 5), and in an early conceptualisation I considered the System Constraints theme as the representation of this presence of an institutional voice in this topography of themes, I then used the labels Student-Self and Learner-Self to contrast what was *expected* of the students by the school (Student-Self) and what the students themselves thought they *needed to do* in order to learn (Learner-Self), thus capturing the essence of the Two Selves.

For example, in the original conceptualisation of Student-Self, the tension was articulated around the institutional voice, as illustrated by Student 3's statement, who presented as their own their teachers' advice in regard to the processes or parameters for doing a task.

> In the exam, we would handwrite on paper as well. So I think it's just better to get in the habit of writing on paper. (Student 3, 226)

On the other hand, the Learner-Self statements were concerned with learning, the accomplishment of the task or the expansion of their abilities. For example, Student 1 demonstrated this when talking about using digital tools to access a body of information to assist the crafting of their work:

> You can use Google to find out information and statistics about things. You can find exemplars of other people's work and get inspiration from them. It's just a really helpful tool. (Student 1, 210)

Another example of this was found in Student 6's interview, when they commented that using digital devices could help them extend their skills: "I feel digital and using a laptop almost extends what you can do. It assists you." (Student 6, 224). Moreover, Student 8, when discussing their use of AI, considered their interactions with AI as a means to extend their knowledge: “[if I ask AI] I learn something more. I put it into my work, so just general knowledge. I could increase my general knowledge or I could also put that into my work” (Student 8, 90).

At the time of conducting the interviews, the College had recently been working with a particular consultant in order to provide professional development around the role of handwriting in learning and teaching. This seemed to be reflected in the school’s guidelines on how to complete tasks as described by the students. This led me to assume the students' comments on the use of handwriting was mere echoing of the institutional voice rather than reflections of their own beliefs. Although this reflective practice led to a change of the label’s name (I will come back to this soon), a dichotomy between the heuristics of good practice and having a grip on the task was clear.

Therefore, this initial thematic distinction was organised under System Constraints, in direct reference to the theory of constraints as a defining factor on skill acquisition (Newell, 1986), and how motor skills are learned and refined. This step provided a framework to start understanding the complex factors influencing participants’ motor coordination development, as well as recognising the interplay between organismic, environmental, and task constraints (as required by the positioning of this study in the field of enactive and embodied cognition). This reference to motor dexterity will become evident to me later on, and it will be discussed in Chapter 6, particularly in relation to the digital.

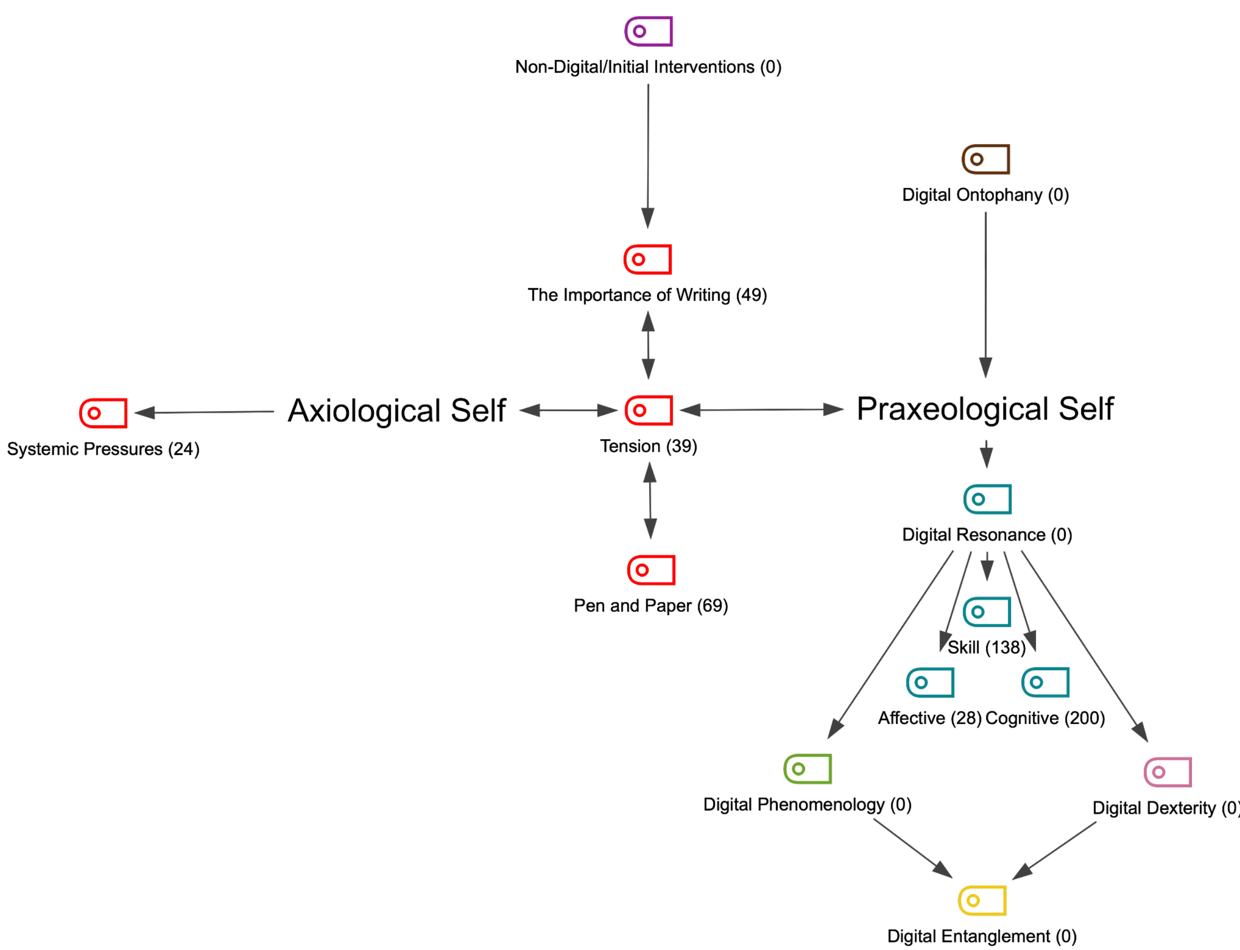
5.2.2.1. Axiology and Praxeology.

The original distinction between Student-Self and Learner-Self was based on my perceived considerations about the ownership of the voices present in the learners’ stories. However, consecutive iterations of the thematic analysis started showing that what I had originally characterised as an institutional voice also included learners’ own preferences and/or beliefs. This realisation led to a re-naming of the labels. Following Biesta’s (2015b) terminology: Student-Self was renamed as Axiological-Self; and Learner-Self became Praxeological-Self.

Biesta (2015b), noted that education research can be divided into two camps or cultures: one that sees education as governed by cause-effect relationships (like in a closed, mechanical system) and those who see education as “a human event of communication” (Biesta, 2015b, p. 12). He differentiates questions of how education actually works (ontology); what it might work for (axiology) and what it means to make it work better in practice (praxeology) (2015b, p. 13). Axiology engages with values, preferences, and what good education is, whilst praxeology regards the judgements necessary in the enactment of education in order to articulate what one seeks. In the context of this research, axiology refers to educational principles whilst praxeology refers to a pragmatic approach to education, where practical decisions are made in the application of the axiological principles. Figure 11 below shows the final distribution of themes that represent the articulation of the narrative of the Two Selves: In the classroom, and when facing a task, students face a dichotomy between "heuristics of good practice" and "optimal grip on the task" and must decide the best way to negotiate it. Their own practical beliefs and some system constraints give rise to a tension. The resolution of this tension would define an axiological or praxeological pathway to complete the task, the former leading to more analogue, the latter to more digital approaches.

Figure 11

The Tale of Two Selves: A graphic representation of the interaction of the main themes in the articulation of the narrative.



5.2.3. Empirical Evidence of the Two Selves Tension

Some aspects of this Tale of Two Selves were evident in the responses to the post observation digital survey (Appendix B section c). The survey responses were collected from students across all subject areas observed: year 13 Physics (15 responses, 28.3%), year 12 History (15 responses, 28.3%), year 13 Art and Design (10 responses, 18.9%), year 12 Art and Design (5 responses, 9.4%), year 12 Media Studies (5 responses, 9.4%), and year 13 English (3 responses, 5.7%).The survey data revealed what seems to be an empirical validation of the Two Selves tension. Despite frequent expressions of preference for analogue approaches, evident both in the interview data and the observation notes (Appendix C section a), students' reported actual device usage patterns seems to tell a different story. Students' self-reported device usage frequency revealed high levels of digital integration. On a five-point Likert scale, 39.6% reported extensive use (level 5), 26.4% substantial use (level 4), 18.9% moderate use (level 3), 9.4% minimal use (level 2), and 5.7% very minimal use (level 1). This distribution indicates that approximately two-thirds of participants (66.0%) engaged in substantial to extensive device usage during observed lessons, providing some evidence what has been theorised as the praxeological self in actual learning practice, even when axiological preferences might suggest otherwise.

Perhaps even more significant than usage frequency was students' perception of the importance of their device usage for learning. Students' perceptions of device importance showed an even stronger positive trend than usage frequency. Nearly half (47.2%) rated their device use as extremely important (level 5), whilst 22.6% considered it quite important (level 4), meaning 69.8% viewed their digital device usage as substantially important for learning. These patterns suggest students perceive device usage as integral to their learning process rather than peripheral, providing empirical support for understanding how the tension between the Two Selves is resolved in practice.

Aligned with these findings, automated sentiment analysis was conducted using MAXQDA's built-in sentiment analysis tool on students' qualitative responses regarding how their devices assisted their learning. The tool utilises a computational approach evaluating emotional tone by counting positive and negative words and calculating the difference between them. The software generates five sentiment levels from "negative" to "positive," with responses containing no sentiment-bearing words marked as "No sentiment." A Stop Word List was applied to exclude neutral grammatical elements, ensuring analysis focused on emotionally significant language rather than being influenced by neutral grammatical elements.

The automated sentiment analysis of 52 student responses revealed predominantly positive attitudes towards digital device integration, providing empirical support for positive affective resonance with digital learning tools. No responses were classified as negative, with only 1 response (1.9%) categorised as slightly negative and 1 response (1.9%) showing no discernible sentiment. Neutral responses accounted for 22 responses (42.3%), indicating students provided factual descriptions without explicit emotional language. Positive sentiment was evident in 28 responses (53.8%), with 27 responses (51.9%) classified as slightly positive and 1 response (1.9%) as purely positive. This distribution evidences that when students expressed evaluative language about their digital device usage, it was predominantly favourable, challenging the students' own axiological concerns about digital devices undermining authentic learning.

The digital survey findings seem to provide empirical validation for the central claims of the Two Selves framework. The strong alignment between usage frequency and perceived importance suggests students engage in substantial device usage because they perceive it as valuable for learning rather than due to external pressures or habitual behaviour. The positive sentiment analysis results indicate students approach digital device integration with favourable attitudes, viewing devices as learning tools rather than obstacles.

The disconnect between potential axiological preferences for analogue approaches and actual digital integration practices (66.0% substantial to extensive use, 69.8% rating device use as substantially important) seem to confirm the existence of a performative tension that students must navigate. More significantly, this tension appears to be consistently resolved in favour of pragmatic digital engagement when students confront actual learning tasks, providing evidence of the contextual sensitivity that characterises the pragmatic resolution of the Two Selves tension.

5.3. Thinking with Technology

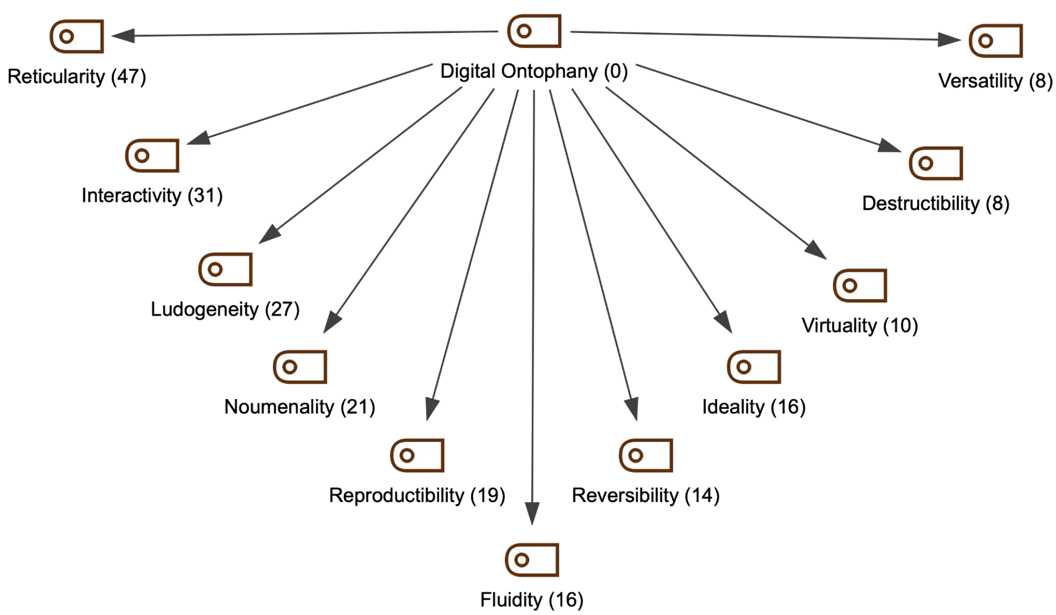
The current section presents the digital aspects of the theme structure, starting with the search of the presence of Vial's (2019) eleven dimensions of the digital in the students' stories, followed by a discussion of the original themes found in this research.

5.3.1. Digital Ontophany

Ontophany is a particular configuration that relies on the correlations between cultural and historical arrangements and their impacts on techniques and perception (Vial, 2013). Digital ontophany, therefore, is a phenomenological event. In Vial's own words, it is "what the possible experience-of-the-world looks like in the digital era, when conditions for exercising perception are conditioned by the digital technological system". (2019, p. 50). Describing that process requires new terms, for which Vial proposed his eleven dimensions or categories. Figure 12 presents a visual representation of Vial's (2019) dimensions of the digital. The number in brackets indicates the number of times these characteristics were found across all interviews.

Figure 12

Hierarchical code and subcode model of the theme Digital Ontophany.



5.3.1.1. Vial's Dimensions of the Digital.

Although virtuality is a characteristic of the digital, it is not the only one, and Vial (2019) warned us not to confuse digital ontophany with the virtual. The virtual is a characteristic of the digital, but not the only one. Vial's (2019) eleven characteristics are also phenomenological concepts that describe the Husserlian (1970) lifeworld in which the digital phenomenon is constructed. The next sections look at the presence of these eleven characteristics of the digital. Each subsection starts with a brief description of the dimension for the reader's benefit, and I will use extracts from the participating students' interviews to illustrate how students' stories reflect these dimensions. It must be noted that, often, students' excerpts illustrated more than one dimension.

Noumenality.

Following Kant's (1790/2008) notion of *Noumenon* (defined as the thing-in-itself, in contrast to that of phenomenon, or the thing as it appears to the observer), Vial (2019) described the digital as something located outside the realm of possible experience. This, he argued, does not mean that it is non-existent, but directly accessible to our perception only through apparatuses or other means rather than directly. Noumena could also be referred to as virtual phenomena (in the sense of non-actual). In Vial's (2019) words, "just like quantum processes, digital processes require technological equipment to appear to us. This equipment is the interface. Whether graphic (visual modality), in command lines (textual modality), or haptic (gestural modality), interfaces are the apparatuses of digital appearance" (p. 85). This idea is reflected in Student 7's description of how, in order to make anything appear on a particular screen, one needs to understand how to bring it into existence first:

> You have to understand how the applications work physically, technically, and you also have to work out how to do it right, and then you also have to design it. (Student 7, 208)

Similarly, Student 2 referred to using their device to bring into existence a world that otherwise would not exist (literally, an alien world):

> I don't think it really exists to [the extent that] I would need it to exist to. [. . .] I know for me there's nowhere that I could have gone that I know of that would be like that. (Student 2, 289)

This digitally mediated form in which things appear or are experienced seems to also be changing some definitions of what things are or should be, which is reflected in Student 9's explanation of how some things should be done or accessed:

> I think there's obviously some scenarios that you have to do things digitally. When it comes down to accessing the internet and saving files especially. And some things are just meant to be done digitally nowadays rather than on paper. (Student 9, 345)

Moreover, Student 8 described AI as something that does not exist other than as lines of code in a server, albeit intrinsically connected to them:

> [AI] it's not something that exists. By exist I mean it doesn't have a soul, it doesn't reside physically somewhere (aside from, probably, the server). It's not an entity; it's not a living thing. It's a computer and evolves. It's always, because it's always learning every time you ask it something (Student 8, 263).

Ideality.

Ideality refers to the notion that the digital world is a compilation of lines of code:

> at each moment in a computer, there is a series of chain compilations allowing high-level languages (which have the highest degree of abstraction and can be read by humans) to be translated into low-level languages (whose syntax is closer to the machine's binary code), up to machine language itself. (Vial, 2019, p. 87)

Virtual worlds are programmable and "all that is digital is abstract and semantic" (Vial, 2019, p. 89). Therefore, coders, programmers, and others have the power to impose or imbue their code with their particular vision of the world. The digital world is an abstraction and a particular formal organisation of symbols and information, governed by particular sets of rules and principles.

Student 5 made this dimension evident when describing how the automated process of selecting works when allowing a device to do it automatically, as opposed to doing it manually: "It would be an automatic selection based on whatever the programme is" (Student 5, 226). Similarly, Student 2, illustrates the programmability of actions and therefore the repurposing of matter, by pointing out how pressing a particular key in the context of a particular platform would produce in a unique result (changing colours rather than entering a space):

> There was a programme that you could just press spacebar and it would go through all different colours that might match, or there were actual colour palettes that you could scroll through and just look at. (Student 2, 257)

Moreover, Student 8 mentioned how each interaction with a particular platform changes it:

> You're just teaching it every time you ask it something. Every time you tell it something correct. It's always learning so it's an evolving tool. (Student 8, 263)

However, Student 7's statement was the most revealing in relation to this idea of abstract, semantic system when, discussing experimenting with free digital platforms in order to mimic what other proprietary platforms do, they pointed out:

> I much more focus on the technical side. [...] The technical side is rule-based. And it is experimenting, is playing with those rules. Playing with the rules and playing with what you're giving it and what it gives back. (Student 7, 270)

Interactivity.

The digital is reactive. Once digital phenomena open themselves to perception, they become interactive. The design of digital technologies is less about the design of beautiful objects and more about the design of the interactions with them. They do not offer the user a mechanical experience, but rather an algorithmic interaction: our bodies do not come in contact with computations, but rather we use interfaces to make it malleable, transforming the noumenon into a phenomenon. Physical actions lead to system reactions in a dialogic relationship where interacting becomes reacting to a reaction: "That's why, to the chagrin of the worried, digital interfaces are very powerful attention grabbers: they endlessly seek our ability to interact with them" (Vial, 2019, p. 91).

Student 7 offered a report on how they exploited this reactive dimension of the digital to create a phenomenological bubble, which is a term I have coined to explain a kind of mini-ecosystem where action and reaction are in equal parts programmable, customisable, and personal. Rather than using one of the more popular web browsers such as Chrome or Edge, Student 7 decided to use Arc. Then, exploiting its flexibility to organise online environments, the student had created within their own Internet browser a unique set of rules:

> Since you can choose what opens up as a tab and what kind of stuff as a pop-up in the settings; I can say that whenever I click out of the presentation it just closes the tab completely. It closes the pop-up. Whereas, if it's a tab, it stays persistent until you manually go and close it, which means that [the window] stays a lot more organised, because everything that you only need for that lesson only opens for that lesson, and anything you need later you can put as a tab so that you can use it later on. (Student 7, 146)

Another example of how interactivity was discussed in the interviews was to continue interacting with their notes even after they were taken. Student 2 referred to this when they said that:

> The good thing about writing on the iPad is you can go back and rearrange stuff and easily remove or add stuff. If you got it in a book with a pen, you can't really move stuff around. (Student 2, 130)

Furthermore, based on the students' accounts, this interactivity between the device and the user changes according to the platform being used at the time. For instance, the typical red line under words, used by many text processors to indicate a spelling mistake, takes on a different dimension and solicit a different kind of action in a coding app. When asked if the platform autocorrected coding, Student 1 pointed out that:

> Yes, a little bit. Just some of the main syntax. But if it's a bit more intricate with variable names, they'll [the platform] just notify you that you've just used it twice, so then you have to just change the name and everything. (Student 1, 386)

Virtuality.

Virtuality refers to the capacity of the digital to create simulated realities (i.e., desktops, folders, albums, etc.) or environments (i.e., the Metaverse). As Vial (2019) explained, "the virtual is the best visible representative, on a phenomenal scale, of the computational matter that operates invisibly at the noumenal scale. Only virtual environments succeed [. . .] in embodying the digital noumenon in the field of our perception" (p. 95). Virtuality makes visible the invisibility of the noumena, by creating worlds with which we can interact. This was made manifest by Student 7 when they described a live E-Sports streaming event. They overlaid different layers of programmable matter (video, score, commentary, etc.) to create a unique space that mimics the experience of watching sport on regular media:

> This is E-Sports, and this is a live stream. So, this is us streaming other people's games, and you are adding, at the same time that you're streaming that, an overlay with extra information. So before the stream, I was creating overlays with the team so we know which side viewers teams are on, then they'll know the current score and things like that. And like they can tell who's talking, because we have casters who are talking over and stuff like that (Student 7, 179-181).

Student 6 also discussed the creation of simulations as they commented on How digital image-editing platforms can simulate visual effects that previously could only be achieved manually:

> You could say it's, well, it's fake. Like with the new Photoshop and things like that. You can replicate physical things. So I can basically warp text, but 10 years ago the only way you'll be able to do that [was] to scan it in a scanner. (Student 6, 143)

Moreover, by compiling portable functionalities that in the past would have been contained within particular spaces, those associated spaces seem to become simulations even though the particular applications or platforms to do so never intended to present it as such. As it is the case of Student 1 referring to their device becoming a sort of substitute for the library:

> I guess you just have access to so many things and so many helpful resources that you're not dependent on going to the library, checking out on books and everything. Whereas on the device you can just access it easily and get as much information as you can. (Student 1, 190)

Versatility.

Versatility refers to the daily reminder that living in a digital world means living with the possibility of bugs, faults and disruption, since “digital material is necessarily matter that falter” (Vial, 2019, p. 95). A digital device does not exist without bugs, because programming language cannot be fully mastered a priori, as it evolves from the iterative process of problem-solving. Similarly, not all possible commutations can be pre-checked, which can result in unexpected consequences. As Vial (2019) stated “living in digital ontophany means living by the side of unstable matter to which we entrust everything, but without ever being able to trust it completely” (p.95).

Versatility not only means living in the acceptance that things can go wrong, but also that, at times and seemingly randomly, faults occur. An example of this, again, is a single unresponsive pixel in Student 7 E-Sport casting:

> I had it set [the background] to a solid green, but when I exported it as a video there was a one-pixel-wide section where the green was a different shade, so when I green-screened it that part didn't cut out. And so now, when you run the animation, there's just a single line of green in front of it. All right. So sad… (Student 7, 286)

Student 9 also referred to this instance of living with the possibility of faulting, when they addressed the reliability (or lack thereof) of digital devices:

> The problem is that I don't think that devices are completely reliable for things as much as paper is. Because the thing about devices is things like data corruption, data loss, crashing, and kind of just hardware failing, like braking and stuff. (Student 9, 345)

Reticularity.

Reticularity refers to the “networked” quality of the digital. However, this does not necessarily refer only to the physical interconnection of devices (for example over the internet) but to the fact that interconnectivity (amongst people, for example) is a phenomenon facilitated by digital devices. As Vial (2019) noted, “there is always a technological device between others and ourselves” (p. 97). Social connections (and other interactions), therefore, are shaped by the digital. As the mechanical machines once impacted the ways in which people related to each other (as in the case of the telegraph or the telephone allowing remote communication), the digital promotes new ways of living and interacting with others (hyperpresence). The digital becomes an otherphanic phenomenon (in the sense that it “mediates” the “other”) in which social connections are realised via a new structure of sociability.

Some of the participants referred to how digital devices not only facilitate this socially interconnected aspect but make it ubiquitous, even in the classroom:

> I always keep an eye on my emails, because sometimes in the middle of classes things come through and I have to… So if it's not urgent … I just see that I've gotten an email and it's fine. But if it's an urgent thing I have to quickly respond to, I would. I can be able to quickly respond to it. (Student 7, 73-74)

Other participants referred to the interconnected aspect of the digital, and how this interconnectivity with other platforms, people, and spaces was bringing everything to their fingertips from a single point of access: their device. Often, these kinds of statements would be associated with the use of the term “efficient”, like in the case of Student 8, who, when answering to why devices were more efficient, stated that it was about “time. Resources are all in one place, like the National Library. I was on and you don't have to think, work too much. It's just at your fingertips anyways” (Student 8, 300). Student 2 also saw the reticular aspect of the digital (in the sense of connecting platforms) as positive when describing the process of writing an essay on a digital device:

> While I'm using the device, this is one of the pros of it. I can obviously go straight to dictionary.com or thesaurus and find the word I'm looking for, because my mind likes to know what I want to say, but not know the word for it. So I can look up a word that relates to what I'm looking for and then just continuing to look up words like that. (Student 2, 228)

For other students, though, this interconnectivity was also a cause of distraction, like in the case of Student 5 who commented that, "when you have your computer, it's really tempting to just go on other stuff and do other things" (Student 5, 340).

One of the most interesting insights on reticularity was gained from the interview with Student 1. They discussed the use of their devices to access support in writing an essay, noting that "we have the online resources as well to just help us with synonyms, definitions, and tenses and everything" (Student 1, 90). They also illustrated how connecting with online content helped them with their creativity when writing: "A lot of ideas happen just from viewing things, so I am able to just craft it and make it even better online" (Student 1, 134). However, they quickly started referring to interpersonal aspects not linked to resource accessibility: "I'd say [it helps me] referring to other people's text, not directly copying them, but definitely the ideas of them … Then also just connecting with others through email and then social media as well, just so I can stay connected and help each other out" (Student 1, 174). Since Student 1's physical demeanour changed as they spoke about being connected, I followed this embodied change with a few questions about how "feeling connected" helped them with their essay writing. The answer included aspects such as "feeling comfortable" (178), "free" (182) and that being connected allowed them to "be able to get the best out of me and all the information I can have (198).

Reproducibility.

The digital phenomena can be copied. It produces instantaneous, reproducible items. Reproducibility, therefore, refers to "the actual technological possibility of instantly generating potentially infinite copies of the same element, image, sound, book, or whatever" (Vial, 2019, p. 99). Some of the participants referred to the capability of certain digital platforms to reproduce or mimic others, like in the case of Student 7, who described using free access software to emulate what proprietary ones could do: "I'm thinking of how to use [it] to create the same effect but with the software that I own" (Student 7, 194). Others attributed the digital with the capability to both immortalise and create endless copies (or versions) of their work, without losing or damaging it: "Digitising my physical work just immortalises it" (Student 6, 228). In a separate statement, the student further developed this idea by saying:

> I have it forever. Instead of having a physical artwork which is only one of them. So I can always print it off if I want to. I can always reuse use it if I want to. [. . .] Immortalising it just brings it so you can use it again you can give it away. You can sell it. You can do whatever. (Student 6, 232)

Reversibility.

One of the most important benefits that digital phenomena offer us is the possibility to start again; not in the sense of reproducing the same thing once again (like re-watching a movie) but in the sense of going back to the beginning and re-start with a blank slate or go back to a previous step and create new alternatives, or other versions of the original artefact. Digital phenomena are reversible, they can be un-done, un-sent, '"cancelled". Vial (2019) noted that "for the user, in the area of phenomenological reception, [reversibility] is big and almost supernatural: it's nothing less than the annulment of the fundamental irreversibility of the physical world to which we belong" (p. 102).

This dimension of the digital is closely linked to a "control-Z" mindset, where mistakes can not only be crossed out, but undone altogether. This aspect appeared to be an important one, particularly in relation to writing and editing online. Expressions of this mindset featured in both pilot and main study interviews with the key participants. Student 2 invested a considerable amount of time discussing this feature:

> You can just delete something and it goes away forever … I don't like making mistakes. It really gets to me. So on a computer where you just have the final version, you know, no mistakes unless you've left a mistake in there [on purpose]. But on paper it's still there. Can't get rid of it. (Student 5, 413)

Reversibility also offer the possibility of deconstructing an artefact, in the sense of experiencing it backwards, tracing its origin from its end. In some ways, this process can be seen as an "undoing of the phenomenon: a deconstruction. In this sense, a particular participant referred to reverse-searching, which allows the user to research backwards, starting from the outcome and reconnecting it with the original inquiry from which it emerged. Student 8 referred to this process in the following excerpt: “I could use my device to reverse search that image and find resources that talk about this image in particular” (Student 8, 148).

Student 6, also talking about essay writing on devices, referred to reversibility as a characteristic that allowed them more control: control to both delete, but also to bring back:

> I find I have more control of whatever I'm writing, and so I can separate what is unorganised and delete that, instead of crossing it out and tweaking it or whatever with a pencil. So I find more control over my work, and that's the organised part I have more control and more organisation of whatever variety. Because I can delete, I can bring back, I can add full stops. I can do that. And which is what pen and paper I can't. (Student 6, 424)

Destructibility.

Computational matter can (apparently) fade away without leaving a trace. Only “a simple hiccup in electrical power is enough for everything not saved in memory to literally and irreversibly disappear from one’s field of reality” (Vial, 2019, p. 125). The common adage that “nothing is lost, nothing is created, everything is transformed” seems not to apply to the digital, since “after a power failure, the amount of unbuffered computational matter in a computer’s RAM memory literally disappears without transforming itself” (Vial, 2019, p. 104), introducing an ontophany of disappearance to which we are slowly becoming accustomed. This destructibility can be intentional (as in the case of reversibility) or unintentional (as in the case of versatility). What makes it unique is the impossibility to go back not even to the broken pieces that once constituted the whole. Digital phenomena can be gone forever.

There was a certain perception of this potentiality of disappearance; for example, Student 3 commented that they were careful before deleting parts of their notes in case this deletion meant permanent destruction:

> If it's something that I can remember, just a few words, then I'll just rub it out and rewrite it. But if it's a long thing, like a definition, then I would move it aside and then write it and then delete it. (Student 3, 186)

Student 2 paid special attention to the process of making mistakes disappear:

> You can change words really easily. You can just delete something and it goes away forever. If you've done it like a day or two before it might still be in your history, but if you're doing it, if you've just written it and then you think it doesn't work, you know, just gone: poof! (Student 2, 401)

Fluidity.

Vial (2019) defined fluidity, or thaumaturgy, as the manipulation of objects to create wonders or to perform magical deeds applying esoteric knowledge. A pseudo miraculous phenomenology where things lose their gravitas to become light and fluid and bend to our expectations. Vial explained that "everything we can do with computational matter seems easy and light, immediate and simple" (p. 105). Everything seems to glide, to just happen, to occur somehow magically.

This lightness was reflected in the way Student 9 described the process of online submission of their work:

> It comes just the tools provided by Google, such as Google Classroom. You hit your 'click hand in' and it just kind of gives a copy to the teacher for marking. So we use the device. Clicking another button, basically quite simple. (Student 9, 389)

Another example of students' perception of this ease of use was found in the interview with Student 2, who used a magic metaphor to describe what happens to their errors or editions in their writing once they are deleted:

> Gone, pretty much. Like if a magician was grabbing a rabbit from a hat and was putting it back in the hat. That's not right. Like if a magician was holding a blanket and somebody was behind it. They drop it, and the person's gone. (Student 2, 409)

Ludogeneity.

Although ludogeneity can be associated with the notion of gamification, the two concepts should not be conflated. Whilst gamification refers to the transfer of video-games structures and culture into other areas of the social (e.g., education), ludogeneity refers to the way in which the digital appeals to our "'playful attitude' even though they are not (and do not attempt to appear as) video games" (Vial, 2019, p. 108). Ludogeneity, therefore, designates the spontaneous promotion of a playful attitude in exploring how the digital interface reacts to our interaction.

Student 8 referred to a few instances of when they were using this playfulness as a strategy to progress their inquiry:

> I used that same text I put it into the AI chat, and I just say 'reword' or 'provide me this same message in a different tone' or 'from a different perspective', [let's] say from the perspective of a historian. Or the most famous example: teach me this like I'm five years old. Just like that, I could say teach me X like [I am] a five-year-old, and it would simplify everything. (Student 8, 230)

Student 7 referred to their inclination to experiment with their device: "I've just experimented a lot with devices over my time. It's like the reason I got Arc. It was just because I like experimenting with browsers" (250). Student 7 also used a similar experimenting approach when using free software to mimic outcomes that they could produce using proprietary ones:

> I used YouTube a lot. I was watching how to create different transitions and different overlays and effects and things. And, since I don't have the software that they use (they have [Adobe] After Effects and it's very expensive). So I was recreating the things with the software that I had at hand. So I had to use things like Keynote, which is a presentation software, but since I knew what I wanted as the output I could make it from what I had. (Student 7, 185-186)

Student 6 used the same exploratory and playful strategy to improve their design since using their device afforded them a broad degree of freedom in changing aspects that they would not be able to change if they were working analogue:

> I can use [digital] to overlay [my artwork]. I can use [it] to make things look more colourful, because it's a bright colour and even then I can bring these physical aspects and combine them with um digital. Because I can change the colours, I can change everything. I can change textures. So it sort of just broadening what I have so I can make more. (Student 6, 220)

Skeuomorphism, which can be defined as "an object or feature which imitates the design of a similar artefact in another material or technique" (Page, 2014, p. 130), could be included as an aspect of ludogeneity. In the digital world, skeuomorphism refers to the inclusion of digital versions of real-world artefacts, for instance sticky notes or rubbish bins. Their use does not add any further benefit that its linkage to the original artefact mimicked and it could be replaced by a non-mimetic object. Student 3 referred to skeuomorphism when discussing their use of simulated sticky notes to add (particular) information to their notes:

> I just use the sticky notes to add, not random, but relevant, but not that relevant information that I need to remember. So it could be like, example, exam tips, some questions they might ask in the exam (Student 3, 142).

5.3.2. Revised Digital Ontophany

It could be suggested that some of the distinctions Vial (2019) made between mechanical matter and digital phenomena in order to illustrate their dimensions may somehow overemphasised some aspects. For example, in the case of reversibility, although re-starting a material phenomenon would require more effort and complication than that of a digital one, it would be inaccurate to argue that material phenomena are always irreversible. The uncountable amount of variation involved in material phenomena would prevent generalisations. The same can be said about destructibility. The "fading away without traces" argument can be countered by the fact that there are always material remnants of disrupted processes, as a forensic analyst would argue. However, taken collectively, and adapting some of Vial's initial definitions, these eleven characteristics can be taken as the hallmarks of a digital ontophanic sensibility. This sensibility (supported by its identification in the students' interviews) was a first step in the interpretation of the data. It introduced the first confirmation of the digital structuring of the students' perception.

Table 9 presents a summary of Vial's (2019) characteristics of the digital with a simplified description of each characteristic, to serve as a guide for the next steps of the analysis that look at the interrelation between them. Some descriptions have been slightly modified to accommodate some missing dimensions, like that of reticularity, where the primordial aspect of interconnectivity has been extended to include the affordances of the interconnected platforms and not only the social aspect of that interconnection.

Table 9

Simplified description of Vial's (2019) dimensions of the digital.

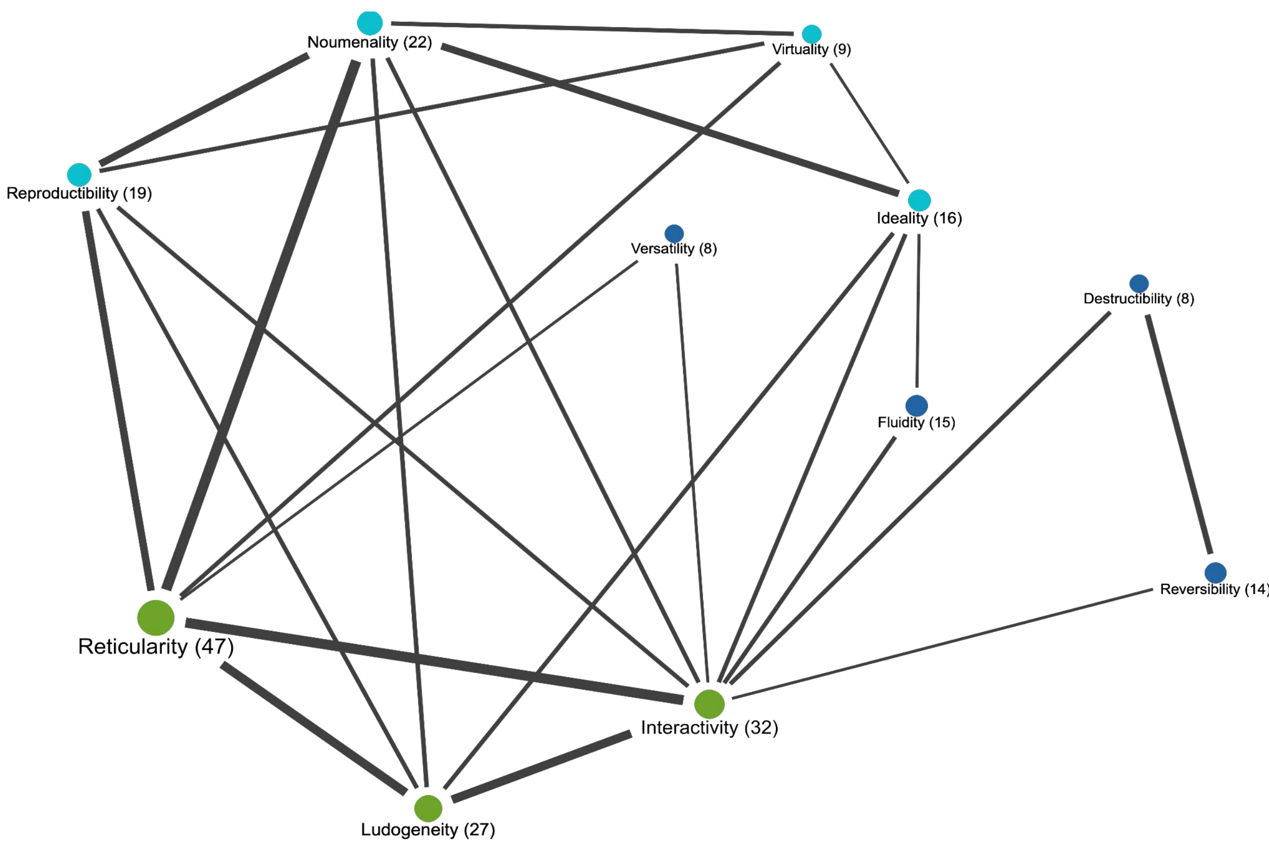
Dimension	Description
Noumenality	Virtual phenomena is only perceivable through an interface
Ideality	Programmable, synthetic - a patchwork of compilers
Interactivity	Not a direct body action but an interaction with a system interface
Virtuality	The capacity of graphic interfaces of creating simulated realities
Versatility	Instability - living with the potentiality of bugs
Reticularity	A social reality shaped by the interfaces' affordances
Reproducibility	Instant, infinite copyability
Reversibility	Cancelability - the possibility to re-start
Destructibility	Immaterial existence that is prone to disappear
Fluidity	Light, immediate, simple, and magical
Ludogeneity	Playable - explorable

5.3.3. Ontophanic Triads

Once I identified the presence of Vial's (2019) characteristics for the digital in the students' recounts of their learning experiences, I started to explore the possible interconnections between the different characteristics. By using this analytical strategy, I intended to capture not what singular dimension was the most frequent, but to identify their proximity in use. That is to say, inquiring if the way in which they come together might operate as a hypothesis that could reveal the scaffolding of the construction of digital artefacts. MAXQDA, the software used for the ethnographic qualitative analysis, was used to visualise the intersection of Digital Ontophany codes in the same interview segments. This visual representation counts the number of times different codes have been assigned to same segments. For codes to be counted as intersecting, they must overlap on the same segment, but not the full extent. Figure 13 shows the interconnection (on the same segment) of the different codes for Digital Ontophany. In this visual representation, the thicker the line, the more interconnections there are between the codes.

Figure 13

The interconnection (on the same segment) of the different codes for Digital Ontophany.



Note: The value in brackets shows the code count. The thicker the line, the more interconnections were counted.

The data thus suggests the presence of three distinctive triads: (1) Reticularity, Ludogeneity, Interactivity; followed by (2) Reticularity, Noumenality, and Reproductivity; and finally (3) Noumenality, Virtuality, and Ideality. This interconnection might signal a defining hallmark (or characteristic) of the digital. As I tried to make sense of the interconnection, a pattern of similarity with Stalder's (2018) conceptualisation of referentiality, communality, and algorithmicity started to appear. The next section explains the salience of these triads.

5.3.4. The Digital as a Structure of ~~Perception~~[3] Society

The triads in which Vial's (2019) digital characteristics interacted in the data revealed a topography that mirrored Stalder's (2018) conceptualisation of the digital as the structure of society. Vial (2019) argues that the digital changes perception. His eleven dimensions of the digital are an accurate representation of the nature of the material of the digital technological system. These properties can be diffractively read through their dialogue with what Stalder (2018) calls the key forms of the digital condition: referentiality, communality, and algorithmicity. Diffraction (Barad, 2007) is a methodology that facilitates a posthuman reading and understanding of entanglement (Ceder, 2020), by disclosing "a reality that already exists amongst the multiple realities being enacted in an event" (Taguchi, 2012, p. 275). That is to say, uncovering a possible reality through making new findings intelligible through the description of emerging patterns from this encounter. Stalder (2018) key forms, therefore, offer a lens through which to understand not only the digital age but also digital artefacts.

Referentiality can be defined as "the use of existing cultural materials for one's own production" (Stalder, 2018, p. 5). Communality is "a collectively shared frame of reference [through which] meanings can be stabilised, possible courses of action can be determined, and resources can be made available" (p. 6); whilst algorithmicity refers to "automated decision-making processes that reduce and give shape to the glut of information" (p. 6). In true diffractive reading, it is only when considering the purpose of each triad in relation to those of the key forms of the digital condition (Stalder, 2018) that the characteristics of digital artefacts emerge. The properties of the digital artefacts become unveiled because, as Stalder argues, "most of the cultural processes operating under the digital condition are characterised by common formal features such as these" (2018, p. 58).

[3] The strikethrough is used as a strategy to indicate the transition from Vial (2019) to Stalder (2018) in relation to the reading of ontophany as a structure of phenomena.

Figure 13 (above) offers a particular structure of triads. In turn, overlapping these triads with the digital condition key conceptualisations offer a unique perspective to understand the properties of digital artefacts: Vial (2019) provides the material characteristics of each triad, whilst Stalder (2018) provides the teleology. By artefact I refer to a product that, due to extraneous intervention and/or human agency, presents itself as artificial in character (e.g., a vase, an axe, a piece of glass, etc.). By digital artefact, I refer to a product that has been intervened, altered, or created via or through the use of digital technologies (e.g., a digital picture, a simulation, an avatar, etc.). Each of these groups are governed by different sets of characteristics and malleability. In this diffractive reading, the digital reemerges not as a structure of perception, but also as one of action, and therefore (hence explaining the intentional strikethrough in the section's title), a new structure of thinking due to the impact that its unique dynamics of material engagement has on cognitive processes.

5.3.4.1. The Interconnected Triads: A New Structure of ~~Perception~~ Thinking.

In the next sections I would like to introduce what might be a contribution towards a better understanding of digital artefacts and the way we think with them. I make this tentative claim of a contribution based on three overlapping premises: the first relates to enactive and embodied principles that argue that we think with the world around us (for details, see Chapter 2, Section 2.5). The second premise is linked to material engagement (Chapter 2, Section 2.6) and how cognitive niches are constructed according to the ways in which we resonate with our ecosystems (Chapter 2, Section 2.6.1.2). The third one relates to onto-epistemology (Chapter 2, Section 2.3.1.2) and the inseparability of being, knowing and doing. By bringing together Vial's (2019) characteristics and Stalder's (2018) conditions, interconnected by the analysis of the data collected in this research, it is possible to (1) identify three triads that define the ways in which digital artefacts are *characterised*, *accessed*, and *circulated*; (2) attempt to define the characteristics of digital artefacts; and (3) provide a background to facilitate the understanding of Chapter 6: The digital as a new structure of ~~perception~~ learning as a form of ecological resonance.

As explained in 5.2.3 Ontophanic Triads, three triads were identified: (1) Reticularity, ludogeneity, interactivity, followed by (2) Reticularity, numenability, and reproductivity and, finally, (3) Noumenality, virtuality, and ideality. The thickness of the line in Figure 13 is directly proportional to the number of codes present simultaneously in the same interview section. Based on these co-occurrences, I numbered the triads in descending order of eventuation (i.e., 1 has more counts of co-presences than 2; and 2 has more counts than 3). To name the triads, I considered the characteristics that were co-present and interrogated myself: what are these characteristics trying to do? If an object had these characteristics, what would they be facilitating? Once again, Vial (2019) provided the material characteristics, whilst Stalder (2018) provided the teleology. Or, in Petitmengin (2021) terms, Vial (2019) provided the landscape and Stalder (2018) the architecture that defines the micro-gestures of thinking with digital artefacts.

Thus, the naming of the triads weaves in the individual characteristics of the interconnected qualities of Vial's (2019) characteristics. They answer my own questions of: (1) what are these characteristics trying to do? And (2) If an object had these characteristics, what would they be facilitating?

Explorability. This triad is constituted by the overlapping of reticularity, interactivity and ludogeneity. This triad identifies the interconnected nature of the digital as a physical network that not only shapes access and presence of resources but also as a meta-structure of social interactions. The ever-expanding nature of this network, both in size and formats, and its responsiveness constantly invites us to playfully navigate it, creating new connections, sense-making, and/or knowledge construction as we do so.

Constructability. This triad is constituted by the overlapping of, again, reticularity, noumenality, and reproducibility. This triad allows (particularly by its interaction with the third triad) to constitute digital, shareable objects. That is to say, this triad enables the emergence of new digital artefacts and their circulation.

Artefactuality (Nomadicity). This triad is constituted by the overlapping of noumenality, virtuality, and ideality. This triad brings into existence the constitutive characteristics of digital artefacts, and it is the core engine of ontophany. Although artefactuality would be the best name for this triad, in order to avoid misunderstandings (such as in expression like "digital artefacts are artefactual"), I also propose the name Nomadicity, in the sense of movement and change (as digital artefact can be re-shaped as they come into different contexts).

5.3.4.2. Reticularity as a Phenomenological Hallmark (The Dominant Triad).

Stalder (2018) argued that algorithmicity, referentiality, and communality shape our current cultural environment. He pointed out that, under the ubiquitous presence of the internet (what in this study is referred as reticularity) individual forms transcend their original spaces to become entangled:

> [w]ith the emergence of the internet around the turn of the millennium as an omnipresent infrastructure for communication and coordination, previously independent cultural developments began to spread beyond their specific original contexts, mutually influencing and enhancing one another, and becoming increasingly intertwined. (Stalder, 2018, p. 58)

Thus, it is possible to plot these ontophanic triads (the new structure of ~~perception~~ thinking) over Stalder's concepts to attempt a criteria to define the characteristics of digital artefacts. Based on the findings generated from this approach, digital artefacts are:

Explorable: the digital by enabling an interconnected, extensive modus of accessing phenomena standardise ***algorithmicity*** as pre-sorted, machine-based shaped structure of perception and action.

Nomadic: the digital by enabling particular ontophanic qualities also enables unique ways in which these artefacts can interact, therefore mutating the process of ***sense-making*** and therefore the referentiality ways in which we think-with-things as a collective.

Constructible: the digital structures a particular form of ***exchange and circulation*** (communality) by enabling the emergence of new ways of being and doing and, therefore knowing.

In this light, the students' selection between the axiological and praxeological self becomes even more salient, as it might define a differential operational dynamic.

5.4. Summary

The present chapter presented an overview of the system of themes and codes emerging from the thematic analysis and offered a narrative to weave them into the Tale of Two Selves, a continuation of the initial metaphor of the Tale of Two Schools. The Tale of Two Selves focused on the tension between non-digital and digital strategies as an articulation point for the performative resolution of the learners' identity. I discussed how initially I thought of this dichotomy in terms of Student-Self and Learner-Self, considering a possible interference of institutional voice, only to realise that these ideas could only be considered part of the learners' belief system. The dichotomy was then presented in terms of axiology and praxeology, bringing attention to issues of what learning is and how it is manifested.

Then, after demonstrating that Vial's (2019) dimensions of the digital were present in the students' descriptions of their experiences of learning with digital devices, I pointed out how the interconnection between them seems to indicate a set of characteristics of digital artefacts. Bringing together Vial's (2019) and Stalder's (2018) theories of the digital, I proposed a revised version of the digital as a structure of perception and action that defines the ways in which digital artefacts are characterised, accessed, and circulated; or in other words, that defines digital artefacts as explorable, constructible, and nomadic. Under this light, students' selection between the Two Selves becomes particularly salient, as it might define a differential operational dynamic.

Chapter 6. The Digital as a New Structure of ~~Perception~~[4] Learning

6.1. Introduction

The present Chapter is a continuation of the micro ethnographic findings and builds on those presented in Chapter 5: Thinking (with Technology): A Tale of Two Selves. The description in this chapter is focused on the Digital themes (Digital Resonance, Digital Phenomenology, Digital Dexterity and Digital Entanglement). The findings seem to suggest that the properties of the digital create a cascading effect of resonance between students and their digital ecosystems. Participants' excerpts are utilised to demonstrate these ideas. The analysis of the themes presented here reflects the endeavour to understand the dichotomy presented in the previous chapter, between the declared student preference for analogue approaches and their final digital interventions. It reflects the search for the microgenesis of those actions. The findings suggest an incipient structure of perception-action of which students themselves might not be fully aware of. These findings seem to align with Petitmengin's (2021) observation that ideas first appear as a direction of thought, a gesture, or a particular rhythm in a moving landscape. That is to say, the inhabitation of digital topographies seems to be creating particular landscapes from where the architecture of the experience and thinking itself arise.

6.2. Ecological Resonance

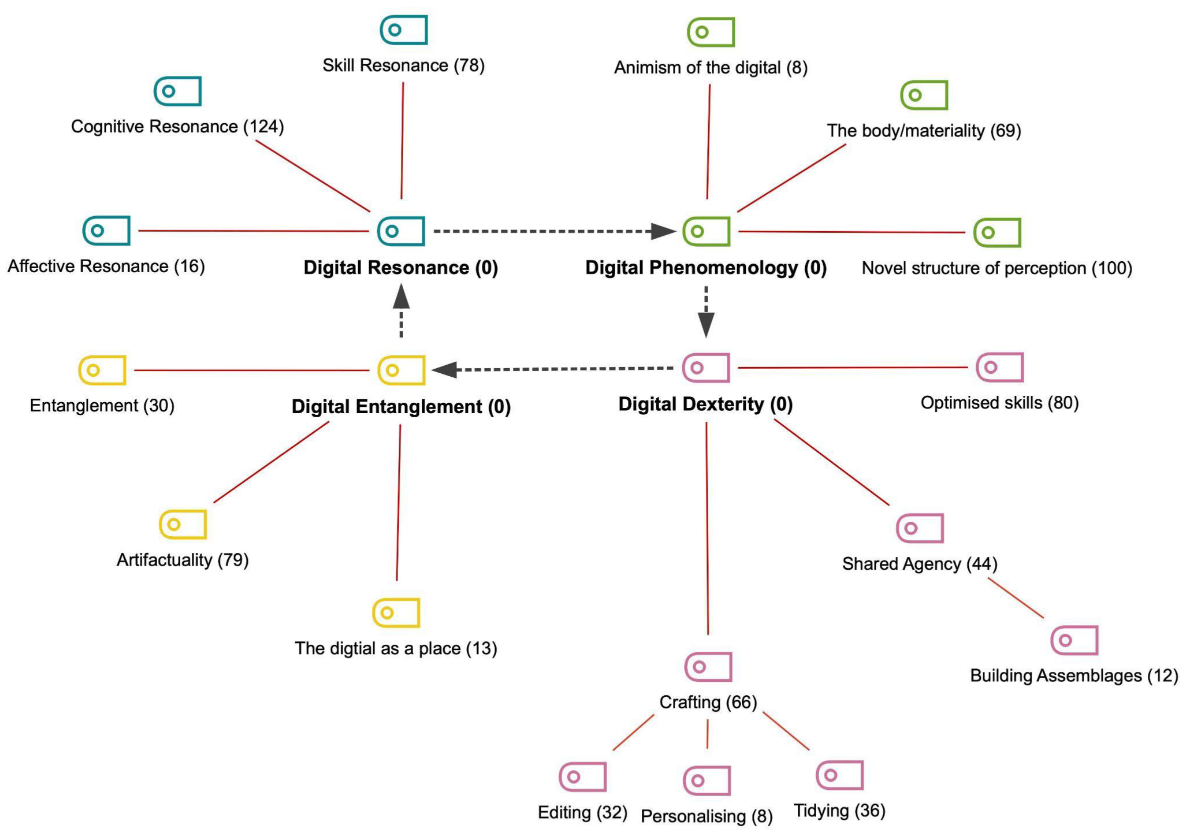
In the previous sections, I started two lines of arguments that I intend to bring to a closure here. The first one relates to the initial finding of the thematic analysis that identified that the students referred to two sets of experiences: axiological and praxeological approaches to learning that were bridged by a tension that they had to navigate. The resolution of this tension directs them towards a particular version of their performative identity. The second line of argument is that Vial's (2019) dimensions for the digital were present in the students' recount of their experience of learning with digital devices. Moreover, the differences in resolving digital and non-digital challenges might relate to a fundamental difference concerning material engagement with the

[4] The strikethrough over the word perception is used as a strategy to indicate that I am applying ontophany no longer as an explanation of perception but of learning.

digital (the resolution of the Tension). That is to say, the digital not only constitutes a different medium but might even have its own governing properties. This section explores the remaining themes from the thematic analysis that emerged from this particular digital ecosystem. Figure 14 shows the digital theme map for the themes discussed here. The main themes are at the centre, whilst the codes and subcodes are positioned outwards. The dotted lines indicate a cascading effect that is addressed next.

Figure 14

Ecological Resonance Themes' Map



Informed by an understanding of learning as an organic and embodied process based on the inseparability between being and the way the world appears to us (Maturana & Varela, 1980, 1987), the following sections describe the main themes that characterise this new structure of perception and action in practice. This chapter will look into the themes not described in the previous chapter: Digital Resonance, Digital Phenomenology, Digital Dexterity, and Digital

Entanglement. Although each theme can be read independently, I present them in a particular order. This proposed order is an interpretative endeavour that reflects Gille's (1986) concatenation of technological systems. This cascading effect is illustrated by the following argument: (1) students resonate with their digital devices at an affective, skill, and cognitive level; therefore, (2) they use them and, by engaging in its use, they create a digital phenomenology (a particular way of perceiving the world). As they increasingly perceive the world through the digital, the digital also becomes a way of action; or (3) the way in which they act in the world (digital dexterity). Finally, as the digital becomes the place where the world and their bodies meet and their dexterity morphs into a digital one, they find themselves (4) entangled with their devices as a way of being-in-the-world.

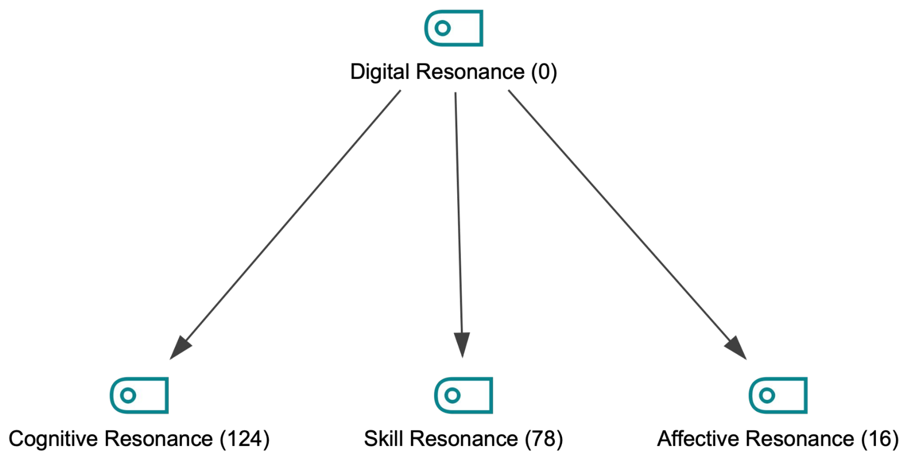
In the next sections, these themes will be examined against the transcriptions of the interviews of the participating students.

6.3. Digital Resonance

The term digital resonance refers to a particular way in which students resonated with their digital devices at an affective, cognitive, and skills processes level. Resonance follows a double association: (1) the work of Raja (2018, 2019, 2021) on perceptual learning and embodiment, where sensorimotor patterns correlate with patterns of brain activity; and (2) Ingold's (2000/2021, 2017) notion of correspondence in the sense that "it is within the context of this attentive involvement in the landscape that the human imagination gets to work in fashioning ideas about it" (Ingold, 2000/2021, p. 257). However, it should be clarified that Ingold's statement refers to correspondence with the natural landscape and not the digital, but it is precisely in this extension of these approaches into the digital landscape where the contribution of this thesis resides. It is, as intended to be demonstrated here, a change of locus but not of modus. Finally, the use of affect, cognition, and skill does not intend to align with any particular theoretical framework. They are used here as simplified labels to indicate when students expressed that they had an affective or emotional reaction when using their devices (affect); when students referred to understanding or completing cognitive tasks with their devices (cognitive); and, finally, when students referred to the completion of a practical task using their digital devices (skill). Figure 15 shows the hierarchical code and subcode model of the theme Digital Resonance.

Figure 15

Hierarchical code and subcode Map of the theme Digital Resonance.



6.3.1. Affective Resonance

Analysis of the interviews showed that students felt particular kinds of connections with their digital devices. Some of those connections were affective, that is, expressions of preference and/or feelings towards the use of digital devices. In some cases, the affective resonance was linked to a sense of 'being connected'.

> I think you just feel a bit more comfortable and you're able to just work at your pace and enjoy it. I feel like when you enjoy something, that's what gets the best out of you. (Student 1, 178)

In other cases, having access to a device helped students' performance during, for example, tests, and that had a soothing effect on them:

> Because I feel that I know that I'm going to be writing faster on a computer. So I feel like I can relax more than rather than typing and also don't have the stress of having to write neat. (Student 6, 401)

Digital devices were also presented as an enabler to the completion of a task that otherwise would have felt too hard:

> 500 Words I don't think is actually too much to do on a device, but it's a lot to do on paper. Like if I was handwriting it word by word it would take me, if I knew what I was writing, probably two hours… maybe three. It would take me a lot longer than it would to do on a device. (Student 5, 369)

A significant number of participants pointed out that digital devices helped them to either personalise or tidy up their work or at least allowed them not to have to consider the tidiness of their work. This seemed to enable them to either have a piece of work to which they feel more connected or focus on other aspects of the task rather than formatting:

> It makes it more personalised, so I understand the notes more and it helps me remember it when I write it down. (Student 3, 102)

Finally, a positive reference emerging from the interviews was that devices allowed students to have everything in one place (both resources and their own work), and that was seen as a benefit:

> Everything is just in one place. (Student 2, 272)

> It's just so I can have one main source of revision. I don't have to have a lot of sources that I jump to and from. (Student 2, 280)

> I guess you just have access to so many things and so many helpful resources that you're not dependent on going to the library, checking out on books and everything. Whereas on the device you can just access it easily and get as much information as you can. (Student 1, 190)

6.3.2. Cognitive Resonance

Students' accounts of their digital engagement also highlighted cognitive resonance as a key property of the digital. Cognitive resonance refers to the ability of digital devices to facilitate intellectual activities. Beyond the assistive quality of digital tools (e.g., Google Docs, predictive text, and others), this sub-theme explores various aspects of cognitive resonance, including the benefits of technology for personal organisation and communication. Digital devices seem to allow students to personalise their interactions with content in ways that better suit their cognitive or perceptual preferences or to access material when and as needed, thereby creating their own *phenomenological bubbles* (a customisable digital mini-ecosystem, highly responsive to the participants' needs and preferences):

> I think for me personally, it was quite important. Because normally if I didn't have my iPad, [. . .] I would just take a picture of it and just look through it when I study for the interview exam. But because I had an iPad, I decided to redraw his mind map. And because I redraw it, I understood more because I had to write down everything he wrote down. And I also colour-coded it to all the different topics, so I could look at it easier. […] But since I redrew it on my iPad, I could look at it easier and look back at it. (Student 4, 148)

> When I took notes last year digitally for some subjects I actually ended up remembering a lot of the content better than my physical notes, just because I would go over them more every single time I opened up the document. Whereas in the physical book, you could just open up to the right page and then half the time you wouldn't even see half of your notes again. (Student 7, 298)

> [When I type,] I'm just able to process it a lot easier than if I was to handwrite it. (Student 1, 102)

Students also discussed connecting with others and other peoples' work, collaborate and find ways to improve their own work:

> I would say, first off, with Google and Google Drive, I can keep all my documents in folders and organise everything in a tidy manner. Then, also, just connect with others through email and then social media as well, just so I can stay connected and help each other out. (Student 1, 174)

Some of the participants pointed out that their devices helped them with creative tasks, particularly around gaining or refining ideas:

> Going through things like that will help me refine it into an actual image in my head. (Student 2, 265)

> The idea begins from our mind but we plot that down on the screen. (Student 9, 106)

Participants also touched on the topic of better synchronicity with their devices than with pen and paper, which allowed them to process those ideas more quickly of redirect cognitive load from handwriting to other tasks:

> If we have an idea quickly, we can quickly type it. Sometimes we can lose track of it if we're using paper. (Student 1, 90)

> I think I remember… I think the biggest thing is that I remember learning about it. I remember being in class that day and then learning about why that happened. Because when I took the digital notes, when I looked back at them, I can remember that class and I can remember how it was taught. Whereas when I look at my paper notes, all I think, I feel like it's harder for me to remember. And I don't particularly know why. (Student 7, 318)

Student 8 discussed the use of devices and AI as an assistive tool to summarise, expand, and find new perspectives in the learning process as they interacted with the AI platform:

> [I would ask AI to] reword the following text to retain the same message in a more simple language, for example, that would tell me everything I need to know plus anything I maybe missed out or forgot about. (Student 8, 212)

The participants found that digital notes are more organised and easier to access than physical notes, and, therefore, they remember the information better:

> It makes it look prettier. So, I write in red colour, the important information. And then I write in white, a description. So the red stands out from the white. So, I'll read a part and I know the red is the important part. And then the white is, if I forgot what it was, it reminds me like what that was … If I'm in a test and I think back on my notes, I can just imagine all the colours and then I can, in my head, I can zoom in on a section and I remember what's written in it. I can see all the colours, if that makes sense. (Student 4, 178)

> I think it's the cohesiveness of the information just keeping everything organised, keeping all of the information in a way that I can quickly go back to it and find like all the information I need without like flipping through a bunch of pages of stuff that I don't remember. (Student 7, 360)

Overall, the participants believe that devices and AI are useful tools for learning. However, they still value the benefits of traditional mediums such as pen and paper for tasks like brainstorming and doodling, because they allow for more creativity and fewer mistakes. This was evident in one of the first interviews, during the pilot. In this interview, the student's description of their process of designing an electric car using AutoCAD (an assistive 3-D design software) prompted the idea of manual drafting and assisted crafting. They referred to how they started the design of the car by hand, mainly because that would allow them to obtain a fuzzy and imprecise first design, whereas if they were doing it directly in AutoCAD, they would need exact measurements and proportions. It might be that the assistive nature of digital devices in relation to crafting abilities imposes certain limitations on the level of fuzziness that initial ideas might need in order to emerge (Petitmengin, 2018, 2021). At the same time, the flexibility and shear number of resources available for students to personalise and customise their digital artefacts not only promoted a deeper engagement (Craik & Lockhart, 1972) with the process of creating the artefact but also a final product that better reflects their learning preferences (Rose & Meyer, 2002).

6.3.3. Skill Resonance

Skill resonance is reflected in participants' suggestions that using digital devices allows them to be more efficient at performing certain tasks and amplify or expand their skills. They indicated that the use of digital devices can improve efficiency and skills in performing various tasks, such as writing, coding, drawing, and researching. Participants mentioned the benefits of using digital tools like Google Docs for editing and refining work, but they also highlighted the generic benefit (beyond proprietary software) to access a myriad of resources that allows them to tackle a task in their preferred way (personalised, optimised, portable). A common recurring phenomenon in several interviews was an emphasis on the malleability and ease of editing and refining. When working digitally as opposed to on paper, participants indicated their appreciation of being able to quickly correct mistakes, refine language, and re-shape their work. By doing this they were left with a "fresh" version of their work, avoiding the distraction of previous mistakes:

> I think [my device] assisted me in making my words feel clearer. Especially what you can do on a device that you can't do on paper. Take out the words and kind of rewrite them when you can't do it on paper . . . for devices you can just use the backspace key and it just gets rid of the keys and you can just fix your mistakes. (Student 9, 397)

Another aspect linked to skill resonance was efficiency, which was a determinant factor for students' preference for using digital devices. Efficiency was associated with several factors, such as speed, tidiness, connectivity, availability anytime-anywhere, and shareability. In two particular cases, efficiency was linked to the economy of resources imposed by the device (i.e., smaller available space for handwriting on the screen) that results in the user's deliberate economy of language, manifested in the careful selection of each word used in the digital notes (Student 4).

Keyboard shortcuts in Photoshop were also highlighted as a useful tool for efficiency. This particular interaction was one of the main precursors of the notion of digital dexterity, which I explore in the next sections. During the observation of one of the lessons, Student 9 told a peer that "[w]ith Photoshop, everything is about keyboard shortcuts". This phrase caught my attention because I found it somehow unusual in the context of a creative subject. Furthermore, during the MP interview, Student 9 conceded that they were not very good at drawing, which led me to wonder where this traditional dexterity needed for drawing was being displaced. What Student 9 was indicating about keyboard shortcuts (as it became clearer as the MP analysis progressed) was a description of his skilled action-readiness, that is to say, the capacity of the body to focus on a particular field of affordances in order to skilfully address a task (Rietveld, 2017):

> With keyboard shortcuts, you can just press a combination of keys or just the key itself and it instantly just selects what you're looking for and it makes it … I especially I think it's much easier to learn Photoshop through keyboard shortcuts. (Student 9, 281)

Some students indicated that using devices extended their skillset and assist you to accomplish tasks in a better or more efficient way.

> Digital [tools] and using a laptop almost extends what you can do. It assists you, right, it does. (Students 6, 224)

Digital devices were described as useful for researching and evaluating sources from a single location (without the need to visit libraries or museums), but also to access information not readily available, which emerged from the interaction with the device. This was evident in Student 8's recount of their use of AI to provide the answer to a particular question from the perspective of several historical figures. Their use of AI seems to offer a unique and transformed, interactive modality of inquiry of data, where user and device collaborate in the process of solving a problem (the inquiry):

> I could say 'assume you're on the personality of a commander. tell me this'. And then using the knowledge [AI] already knows about a commander it'll go and use strategies and say 'maybe this didn't work because let's just say the soldiers were fatigued' or 'this wasn't a very good plan to begin with because it was a flaw'. You could point out flaws very easily too. So that's what I think about it. (Student 8, 288)

Additionally, devices were also used to access information that might prove difficult to find in alternative mediums, such as very specific colour palettes and image searches to refine their creative ideas:

> To find the colours I was using my device. I was looking through all the different colour palettes or colours that work together. I can't actually do that on paper because I don't have every single colour in the world. So going through them would also give me more ideas that I can then translate onto paper. (Student 2, 245)

6.4. Digital Phenomenology

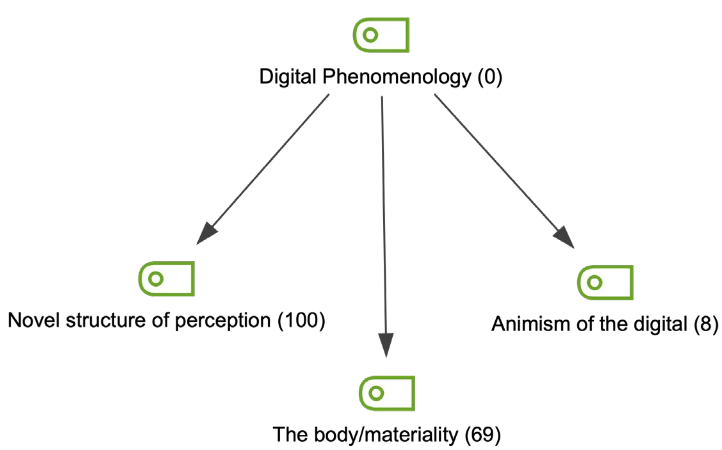
The term *digital phenomenology* refers to a particular way of experiencing the world. I use the term phenomenology not in its academic sense linked to the work of Heidegger (1927/1996) and Husserl (1970) as the study of experience and consciousness, but more in its etymological sense. The word phenomenology derives from the Greek words φαινόμενον (meaning that 'which appears' or phenomenon) and λόγος (study), meaning the study of how things appear. Accordingly, digital phenomenology is concerned with how things appear or are perceived in a digital context. That is to say, a particular kind of occurrence in how things appear, are perceived, or occur is a direct result of digital manipulation.

The previous section presented how students' affects, skills, and cognition resonated with their digital devices. The students seem to have resonated with their digital devices because they perceive that these have the potential to expand their capabilities or at least make them feel better while performing a task. Because of that, students often chose to use their digital devices to perform school-related tasks (and in some cases, they were a requirement). In turn, these affective, cognitive, and/or skill resonances with their digital devices seem to have become, first, a form of predilection and, ultimately, a way-of-being in the sense that students develop affinity with the way things appear to them and are experienced. In Student 6's words, it becomes "a form of muscle memory" (89). Moreover, it can be argued that the persistence in this phenomenological bubble sets the basis for the development of a particular niche (Kirkmayer, 2020) in which students and devices drift together into an incremental dynamic of structural coupling (Maturana & Varela, 1974): they resonate → they prefer→ they inhabit →they resonate more, and so on, in a sort of natural drift (Maturana-Romesín & Mpodozis, 2000).

Figure 16 shows the map of three particular codes within this Digital Phenomenology theme: Animism of the Digital, The Body/Materiality, and Novel Structure of Perception. The Animism of the Digital was present only in three interviews; the remaining two codes, however, were more prevalent. Body/Materiality collects references to the interrelation between the use of tools (digital and analogue) and embodied dynamics, while Novel Structure of Perception contains references to perceiving the digital as a new structure of perception in the sense that it can present things in a different way.

Figure 16

Hierarchical code and subcode map of the theme Digital Phenomenology.



6.5. Body and Materiality

In regard to body and materiality, the students discussed the use of analogue and digital tools in creative processes such as drawing, designing, and note-taking. The interviewees expressed a preference for analogue tools (which at times they refer to as ‘physical’) due to the importance of developing sensorimotor skills, authenticity, and the ability to make mistakes. However, they acknowledged the efficiency and convenience of digital tools, particularly in terms of organisation and accessibility. Student 9 highlighted the use of keyboard shortcuts in Photoshop as a way to improve efficiency. They pointed out how a particular configuration of interaction between their fingers and the keyboard (the actual gesticulation of the keyboard command) meant that they could avoid navigating the menu in a more traditional way. This particular excerpt was one the first ones that made me wonder if digital environments were requiring particular forms of dexterity from users, in the sense of demanding a specific embodied dynamic to responds to a particular landscape:

> Things can be quite hard to find visually. So you're kind of just looking at these when you're, where is this thing that I'm looking for? And you know you're wasting time looking for this thing. With keyboard shortcuts, you can just press a combination of keys or just the key itself and it instantly just selects what you're looking for and it makes it. (Student 9, 281)

Interestingly, in several statements, Student 9 referred to the digital as a place where you could do ‘physical’ things: “it's like a very physical thing kind of but we'll do it online” (Student 9, 98). Student 9 reiterated this later in the interview. In this case, it seemed that some form of manipulation was happening on the screen rather than in the mind:

> It's not like in our mind the idea. Well, the idea begins from our mind but we plot that down on the screen … [It] Is a very physical process that happens on your computer. Not in your mind. (Student 9, 295)

This idea of malleability could be seen as naturally occurring in the context of Art Design that Student 9 was referring to. However, Student 7 also referred to this idea of plasticity, but in their particular context, they were linking the malleability of that space with that of a cognitive process:

> I could use the analogy of it being like a room. Whereas on my device I feel like all of my, let's just call it knowledge, right? All the boxes of content, all of the stuff it's placed really neatly. And it's really easy to be moved. Whereas in a physical book, they can also be described as a place, but it might be like you can't move things around. Once you put things down, they're there forever. (Student 7, 331)

Moreover, Student 9 continued, by manipulating things in this room (your device), an effect could be achieved at a cognitive level:

> So with the device you can play around with your room, you can reorganise it, you can put it in a way that makes you remember better. For when with a physical book, once you've written it in it's a lot harder to play around with it, move it, move things around. (Student 7, 331)

The students' comments about the role of the body and materiality in their cognitive processes were initially overtly in defence of an analogue model. I attributed this, in the first instance, to what I have referred to as the institutional voice. However, it was later evident that, although it could have originally been traced back to the institution, it was now part of the learners' beliefs. Nonetheless, the use of digital devices was often associated with ideas such as efficiency, personalisation and speed. This type of use seems to have opened up spaces for new possibilities of manipulating elements supported by the digital, which in turn made way for new ways of perceiving and manipulating those artefacts.

6.5.1. Novel Structure of Perception

This idea of a Novel Structure of Perception is central to the present study. This section looks at how the realisation that digital manipulation of artefacts could bring along (amongst other properties) more efficient and personalised environments, leads students to develop a further resonance with them, creating a sort of feedback loop. Digitally-facilitated formatting and manipulation become a form of new normal when it comes to forms of perception, since habitual forms of perceiving things seem to be expanded, extended, and transformed by the affordances of digital devices. This might include, at a very basic level, the formatting or transformation of content in a plastic process of adaptation to their own preferences. Student 4, (in an excerpt previously presented) referred to this when recalling how they could not only copy but adapt and expand a mind map in a way that could have been difficult (or at least resource intensive) without access to their iPad, resulting in an increased resonance with it:

> Because I had an iPad, […] I redraw it [and] I understood more […] And I also colour-coded it to all the different topics so I could look at it easier. […] since I redrew it on my iPad, I could look at it easier and look back at it. (Student 4, 148)

Student 3 also referred to this formatting as an important aspect of shaping their notes to their particular needs:

> Often I use colour to label things. So it could just be an equation I write out and then I use colour to label it and say what it is, where it comes from. (Student 3, 162)

This personalised structure of perception not only includes aspects of formatting but can also refer to having the possibility of tracking real-time interactions via digital referencing. For example, when Student 7 commented on how —facilitated by the shareability and circulation of digital artefacts— they could follow the class both via paying attention to the teacher in front of them or following the same digital Google Slide Presentation that the teacher was using and had been provided to them:

> If you missed something that he would have said I could see exactly what he was trying to say. (Student 7, 163)

This navigability is facilitated by the availability and personalisation of digital environments, where reference material is readily available and access to them can be customised. This malleability of the digital seems to also optimise students' cognitive focus:

> I could zoom into the page to see the questions better or focus on just the one part of the questions. (Student 5, 324)

Also, it can permeate perceptive abilities, as when Student 4 mentioned their ability to mentally zoom in on a section and remember what was written in it. Moreover, this malleability allowed students to create environments that behaved in ways that were responsive to their cognitive needs and preferences:

> I open the folder and I'm inside the Google site that all the docs, all the slides are on. And then, from there, whenever I click one of the slideshows, it opens as a pop-up rather than a tab. So usually, on other browsers, it would open as a tab, but on my browser I've set it up so it opens up as a pop-up. So that I can obviously copy, follow along, but then if I need to quickly go to a different thing, it doesn't add a new tab. I can just click out, go to the other thing, and then click back. (Student 7, 114)

AI, arguably, is the platform that has taken this customisation and personalisation to its highest expression, allowing students to not only personalise and manipulate formats but also access artefacts that emerge during the actual interaction and around very specific expectations. This was illustrated by Student 8's description of how they use AI to extend their knowledge: "I can say 'teach me Quantum Computing like a five-year-old'" (Student 8, 69), personalising not only the tone and topic but also the tone and language.

6.5.2. Animism of the Digital

Animism of the digital was the least frequent of the three codes. It also was the least representative (present only in three out of the nine participants). However, it caught my attention, because it seems to demonstrate that some digital platforms (particularly, but not exclusively, AI) are seen both as tools and peers (Lodge, 2024). One example of how this assertion was made evident was by the way students attributed capacities to certain platforms as if they were capable of intentionality, as when Student 1 said that "the programme itself underlines" (Student 1, 374); or Student 5 allocated a state of mind to a programme by arguing that "Photoshop gets confused and cuts out too much" (Student 5, 178). In one particular case, a student suggested that computer might have free will; thus, Student 5 argued that "the computer chooses it as well" (Student 5, 222) and that, "based on what you tell it, it can only assume what you want" (Student 5, 254).

However, the most significant insight in regard to this code was offered by Student 8 when discussing AI:

> Do you know Khan Academy they're using chat GPT4 already? They gave access to it so you can ask questions and it actually tutors and mentors you. It gives you motivation and tells you where you're right or wrong. It's like a tutor but it doesn't get tired from hearing, like a normal person. (Student 8, 292)

Two interesting aspects are present in this interaction. First, an emergent consideration of it both as a tool and a peer (Lodge, 2024) in the sense of attributing the platform the human capacities to tutor, mentor, and motivate; but most interestingly they did not remove personhood altogether from AI, they only qualified it as not a normal person. This new type of inter-"personal" way of relating to technology is a phenomenon that has been noted in the literature (Tranberg, 2023).

As illustrated by the excerpts presented in this section, digital ecosystem malleability and customisation seem to allow users to create hyper-personalised and efficient environments that, by being responsive to their both aesthetic and cognitive needs and preferences, could create certain orientations in relation to how they perceive phenomena, but also in terms of how to interact with them. This requires the development of coupled relations with devices as well as level of proficiency at navigating the complexities of these settings. This seems to be demanding new forms of body readiness in the form of digital dexterity.

6.6. Digital Dexterity

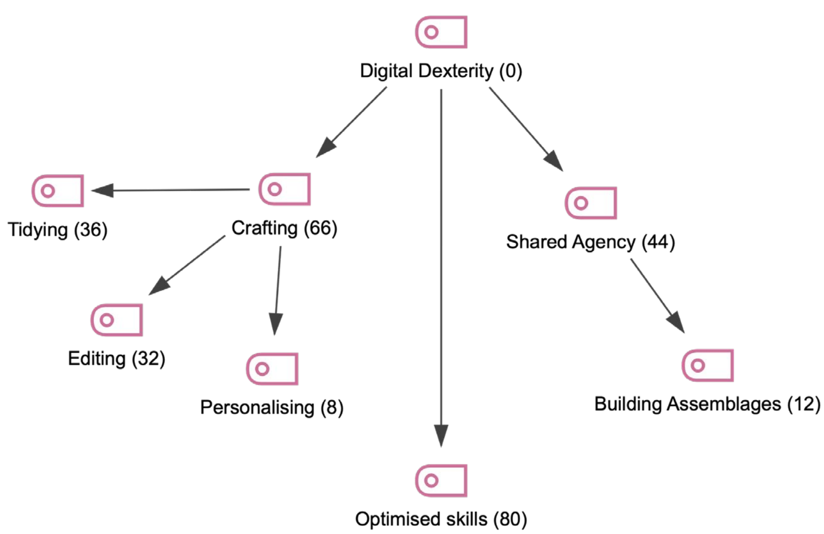
The term digital dexterity has been used in the literature from as far back as the late 60s (Boucher, 1968). This first wave of usage referred to finger (digit) dexterity and, to a lesser extent, grasp. It was not until 2009 (Kapel, 2009) that the term was associated with technology. I could not find any association between the term digital dexterity with user interfaces before 2016 (Nansen & Jayemanne, 2016). However, I prefer to use it in the context of an intersection between the digital and the physical (Cabrinha, 2011) as an indicator that the "intelligence of discernment, of discerning salience, begins at the interface between the body and the world" (Penny, 2017, p. 175). That is to say, that the finetuning of motor skills (Bernstein, 1967, 1996) emerges from the close and repetitive interaction with the environment (even if that is digital). The term is closely linked to how Merleau-Ponty (1962) described intentionality as a non-cognitive and often unconscious bodily skill and disposition towards the world. Intentionality describes a skilful bodily responsiveness where the sensorimotor capacities become the modes of 'being-in-the-world'.

Bernstein (1967) used the term physical dexterity to refer to the ability of the human body to perform skilled movements efficiently and accurately in particular environments. This dexterity is not a property of the movement, but an interaction with a changing environment and it manifests as the capacity to perform skilled movements efficiently and accurately. If the body is our own interface with the world (Merleau-Ponty, 1962) and students seem to keep finding the world in the digital, does that affect the way we interface with it? If organisms inhabit subjective worlds shaped by their sensory perceptions and experiences (Von Uexküll, 1934/2013), the digital seems to fundamentally (albeit incipiently) reshape those experiences (and expectations).

I extended this idea to apply it to these themes. It refers to the series of manoeuvres within this new structure of perception (Digital Phenomenology) that are needed to skilfully respond to and within it (such as eye-hand coordination when using Wacom tablets, keyboard shortcuts articulation, visual tunning to screen cues, etc.). Digital dexterity, therefore, refers to the development of a set of fine-tuned skills or modes of being-in-the-world. These manoeuvres are both physical (particular ways or moving or perceiving) but also pragmatic (the way things "are done"). Once again, the findings seem to reflect Petitmengin's (2021) ideas that thought replays the microscopic gestures and rhythm of particular landscapes we inhabit. This would suggest that students are not just users of devices, but that the devices are integral to their practices. Moreover, these sets of skills can be seen as a form of resonance linked to their inhabitation of the digital. This manoeuvrability was coded under three main codes: Shared Agency, Optimised Skills, and Crafting (see Figure 17). Optimised Skills was used to code excerpts that refer to the optimisation of practice by using digital devices. Crafting (and its three subcodes: Tidying, Editing, and Personalising) contains references to the application of these optimised skills to resolve their drafting into a crafted artefact. Finally, Shared Agency is a reflection of how agency is distributed in the process of crafting between the student and the digital device.

Figure 17

Hierarchical code and subcode map of the theme Digital Dexterity.



6.7. Crafting

From the very early stages of this study, an incipient narrative structure started to emerge in the students' interviews. This incipient structure was defined by a tension between digital and non-digital processes. Digital dexterity was one of the first codes to surface during the thematic analysis as a means to organise the emergence of an initial distinction between manual drafting and assisted crafting. In contrast to drafting, the process of crafting was often presented as associated with editing, a process preferably done digitally. Student 2 presented the transition from drafting to crafting as the shift from" what you want to say" to "how you want to say it":

> [You] draft the sentence or make a sentence with what you want to say ... and then edit it so that it's how you want to say it. (Student 2, 448)

However, this idea of crafting appeared to be associated not only with improving the work but also with the fact of doing the work *from* a digital device:

> Crafting is just making sure that every word that you use is necessary and helps the writing improve so that the reader actually enjoys the piece… Then from the device, you can improve it vastly and make it a lot better for the final submission (Student 1, 278).

Crafting was presented as an iterative and constant process, facilitated by the editability and malleability of digital formats:

> No matter how much you try to keep [your handwritten notes] neat there'll always be some cases where your notes just won't be as neat. Whereas with a Google Doc you can go back and edit it as many times as you need to make it like how you need it and as concise as you want it. So you can constantly keep editing it, whereas paper notes, once you've written them, you kind of either have to rewrite them if you want to make them neater or you have to use white-out and write out a bunch of text. (Student 7, 150)

6.7.1. Optimised Skill

Tidying up and personalising (both the content and the formatting) were operations also reported as preferably done digitally, and this process was associated with some sort of cognitive aid as illustrated by the following excerpt from Student 7. In the excerpt, the student reflected on how their digital notetaking allowed them to constantly reorganise the notes to follow their perceived best sequencing:

> Maybe what you learned one day is more applicable to what you learned a week ago than it is to what you learned the previous day. And when you have a digital note you can just move things around. (Student 7, 343)

It was also often noted that the process of personalising and editing would converge to aid students in organising their notes:

> The lesson was going really fast, so I would usually write my notes more tidily like that. But for that lesson I just scribbled like that because I didn't have time to format it and everything. But this is quite messy, and it's harder to revise with than if it was neatly laid out. I also go back and colour-code things. (Student 3, 158)

Moreover, Student 1 indicated how that malleable process of editing aided their thinking. The excerpt seems to suggest that the thinking about how the work could be improved was in some way linked to the possibility of “swapping things around” (a Digital Phenomenology expectation) since a number of students indicated that this process was quite difficult when working analogue:

> I think I just felt a bit more connected with the device. I was able to think of my writing and actually realised, Oh, I can definitely improve this. Swapped some things around to make it more intriguing for the audience. (Student 1, 154)

6.7.2. Shared Agency

These customising operations included references to a sense of shared agency in the sense that students recognised that the tasks were performed (better) when task responsibility was distributed between the learner and the device. This distribution of agency, however, took different dimensions. Student 1 described their process of fixing a mistake with their coding as a distributed effort: one in which the platform would identify an error and the student would fix it:

> So we got help, obviously, from the Code Avengers website. But if something is wrong, it gets underlined in our coding. So then from there, we're able to understand. Okay, we made an error and then we can just fix it up a lot quicker. (Student 1, 370)

Student 9 also referred to this distribution. Interestingly they indicated how the use of a particular keyboard shortcut could eventuate in the exact outcome they were looking, which can be seen as reflecting a high level of synergetic integration between the user and the device:

> With keyboard shortcuts, you can just press a combination of keys or just the key itself and it instantly just selects what you're looking for and it makes it. (Student 9, 281)

Student 5 also used examples of automated selection. However, in their case, the best approach to solve their problem was through negotiating what part of the task was automated (and done by the device) and what part was manually selected:

> And you can automatically select what you want to cut out. But sometimes, because the photos are a bit old and some of the colours are similar, Photoshop gets confused and cuts out too much. So I cut all of that manually. (Student 5, 178)

As mentioned before, an interesting insight from this excerpt comes from the use of the term “confused” to describe their device; it is a curious selection of words to refer to a digital device that seems to recognise some sort of effect present on it.

One significant code is Optimised Skills. This code groups instances of an improved positioning ahead or within the task as a result of the presence of the digital device. These instances might address the ease of navigating or accessing content, as illustrated by the excerpt from Student 7:

> I think the browser that I use made it really nice. Just because when I opened the slideshows it wouldn't open it in a tab, it would open it in a pop-up so that I could quickly switch between the different ones. If [the teacher] referenced something from an old presentation that I might have been away for, I could quickly switch to it really quickly. (Student 7, 106)

Most significantly, Student 8 attributed their digital device with the capacity to teach them something. This process of learning from the device reflected a highly streamlined learning interaction, where both student and device meet to accomplish the task of learning, but in which each undertakes a particular role:

> So I used that same text. I put it into the AI chat and I just say ‘reword’ or ‘provide me this same message in a different tone’ or ‘a different perspective’, say from the perspective of a historian. Or the most famous example: ‘Teach me this like I'm five years old’. Just like that, I could say ‘Teach me X like a five-year-old’ and it would simplify everything. And that's AI. Teaches you. From time to time it does help me a lot (Student 8, 230).

The excerpts presented in this section seem to illustrate a new way to interact with the world that is characterised by particular forms of resonance and correspondence to an environment populated by artefacts governed by a particular set of properties: explorability, constructability, and nomadicity. The interview quotes presented in this section suggest that an environment populated with artefacts with novel properties requires a novel structure of perception and action and, therefore, the emergence of a subjective world (Von Uexküll, 2013). The interface with this world seems to be both entangled and extended. Entangled with the digital devices students use to mould those malleable artefacts and extended by the properties and increased capabilities of this environment. In this process, however, their bodies do not interact directly with the digital matter (following Vial’s principles of noumenality and interactivity). Rather, digital embodiment seems to emerge as the result of an algorithmic interaction.

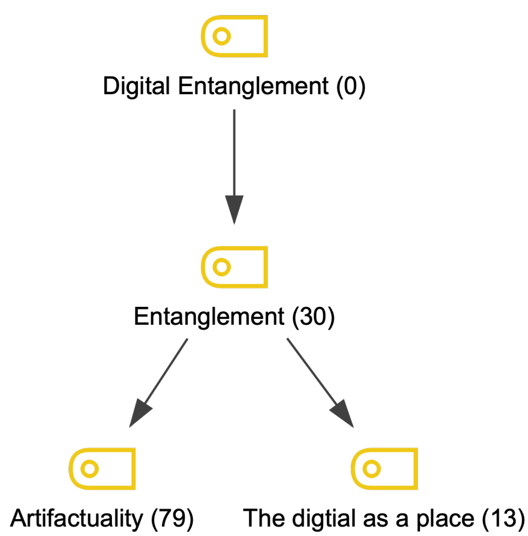
6.8. Digital Entanglement

Digital entanglement refers to how particular ways to act in the world —characterised by an entanglement (of perception and action) with digital devices— seem to be creating a new niche. Digital entanglement relates to the emergence of a digital niche by opening up new affordances and creating an environment of material agency, a coalescence of human and non-human emergent agency. The excerpts in the current section explore how the use of digital devices and tools for note-taking, studying, and design work create particular forms of movement that promote the conditions of resonance and embodied readiness that facilitate the emergence of a niche. In this niche, material engagement with digital artefacts is governed by rules other than the Causal Closure of Physics (CCP) and enculturates our cognitive processes as the cognitive tools become integrated within our cognitive system (Menary & Gillett, 2022). That is to say, cognitive processes are enculturated as a result of manipulating artefacts that are not only malleable in new ways but can also be circulated and combined in accordance with those rules.

This theme presents a single code: Entanglement. This code includes students' statements expressing that they feel connected to digital devices and use them for various purposes, and how the use of those digital tools is seen as a way to enhance their skills and expand possibilities. As Figure 18 shows, the identification of this code relies on the confluence of two sets of ideas: artefactuality and the digital as a place.

Figure 18

Hierarchical code and subcode map of the theme Digital Entanglement.



The concept of artefact used here is influenced both by Sanches de Oliveira (2022) artefactuality and the notion of dynamic cultural epicycles discussed by Thomlinson (2017). Although artefactualism is normally associated with the idea of scientific models as tools, instruments, and artefacts as active components of scientific inquiry, artefacts (as scientific models) are often used to explain and predict the behaviour of real objects or systems. Sanches de Oliveira et al. (2021) extended this notion of artefactuality to thinking. They link thoughts to specific perception–action episodes, therefore drawing analogies between thinking and scientific modelling in that they target real-world phenomena to present a model *not of, but for.* That is to say, "explicit, occurrent thoughts are tools, instruments, or artefacts" (Sanches de Oliveira et al., 2021, p. 121). I have extended that idea of model to include excerpts that feature a proto-explanation of behaviours or phenomena. By doing this, it is possible to identify a process of epicycles, where particular (singular) forms of artefact manipulation are fed back into the immediate environment, adding new qualities to this environment. Cultural epicycles (Thomlinson, 2015) are the process by which, in interaction with a particular niche, the organism produces an artefact that is fed back into the environment, impacting both the environment and the organism (as a newly integrated component of that environment). I use this extended version of artifactuality in this study as a theoretical strategy to (1) challenge representationalism (Sanches de Oliveira, 2022), and (2) focus on their tool-like nature and the role of agency in their construction and manipulation.

Therefore, based on the understanding of some excerpts from this artefactual and cultural epicycle perspective, I argue that these artefacts described in the students' statements are being constructed and imbued with the properties of the digital, then fed back into the niche. From there, in turn, this modified artefact re-impacts both the environment and the organism and is, again, transformed and fed back. These artefacts, due to their peculiar properties, can therefore be thought *of* and used *for* differently, since the material engagement with them (Ingold, 2000/2021; Malafouris, 2013) is imbued with unique properties. For example, students seem to establish a parallel between physical manipulation and online malleability: “It's like a very physical thing, but we'll do it online” (Student 9, 98). These artefacts would, then, make the jump from the screen to the “head”, to integrate into their thinking process: “Going through things like that will help me refine it into an actual image in my head” (Student 2, 265). In that process, these artefacts are entangled in a digital dynamic that seems to transform and imbue them with digital properties:

> Even if [the painting] was discarded, I still have it digitally. So I find that immortalising your physical work means [that] you can bring it back. (Student 6, 236)

Moreover, once they become digital artefacts, they are imbued with new set of features (explorability, constructability, and nomadicity). They can, then, be circulated, transformed and contribute to sense-making in a transformed way. Student 9 illustrates this feature-dependency in the microgenesis of an idea when he argues:

> Different ideas have different features to them […] If we if we mix both features […] you come up with a whole new idea (Student 9, 98)

Students, therefore, create artefacts that shape and are shaped to fit their way of "seeing the world", as illustrated by the excerpt where Student 4 described how the new format of their digitally created mind map made it easier for them to look back or remember (Student 4, 148). These integrated artefacts seem mixed in cultural epicycle dynamics and operate on them according to their particular properties, as afforded by the platforms in use. That is to say, there is an entanglement of potentialities but also of entrapments, in that differently constructed artefacts present particular modes of malleability.

There also seems to be a dynamic where users, devices, and algorithmicity drift together towards the completion of the task, mutually influencing each other. This concept is illustrated in the next example, where Student 2 describes how they tend to search for words. This description suggests that the student's final word choice is influenced both by their intended meaning as well as by the algorithmic possibilities presented to them by their digital device. However, nowhere that impact of drifting seems to be stronger than in the use of AI, as illustrated by Student 8's statements on AI's-human entanglement and recursivity in the construction of knowledge:

> AI is also a tool it's not something that exists but it can curate responses and hold conversations. So it has information. It keeps on getting new information. You're just teaching it every time you ask. (Student 8, 263)

This particular statement seems to involve different layers. First, presenting digital devices as tools that help. Then, describing the internet (the basis of digital reticularity) as a portal to the world; only to add another layer by stating that AI curates that access. This shows an increasing level of algoritmicity in the process, in an interaction described using terms with a high level of 'humanness' (such as conversation and teaching).

Digital Entanglement, then, seems to be the encounter of students and the world in the digital. This place, according to Student 7, is "a lot more logical":

> It's like a place where there are certain rules, that if you follow you can make everything work really nicely. (Student 7, 250)

Furthermore, when asked how they got to know those rules, Student 7 expressed that one learns those rules by experimenting with them:

> Some experiments have the same concept. So with Chemistry, you're experimenting to confirm something. So if I add iodine to starch then the colour should go a certain colour. With a computer, it's like: if I run this command with these inputs then hopefully the output should be the two videos next to each other. But then, obviously, sometimes you do it and, with chemistry, it might not happen. And then you have to figure out how to change your solution. So maybe you're not using iodine anymore. Maybe using a different chemical. So the same thing is applicable to computers, where you might be changing your command a bit. You might be tweaking your settings to make it so that you get what you want as the output. (Student 7, 258)

It seems to be in this explorability that artefacts imbued with novel properties are created and circulated in new ways according to "certain rules": These artefacts, then, enter an epicyclic dynamic that further impacts the digital embodied readiness, creating particular avenues for the development of ecological dexterity via dynamic coupling. In other words: Digital Entanglement becomes articulated by a mechanism in which students and the world meet in the digital in an epicyclic dynamic coupling. Chapter 7 will explore the structure (or hallmarks) of this coupling.

6.9. Summary

The present chapter built on the micro ethnographic findings presented in Chapter 5. It presented an overview of the system of themes and codes emerging from the thematic analysis in relation to the digital, completing the articulation of the Tale of Two Selves. It introduced the four digital themes as a form of ecological resonance with the digital, and it described them as an increasing concatenation (a dynamic coupling) going from the simplest to the most sophisticated phenomena, starting from a form of correspondence with the digital (Digital Resonance), that leads to perceiving and acting in particular ways (Digital Ontophany) that lead to a peculiar embodied readiness (Digital Dexterity) in which students and devices drift entangled. Digital Entanglement, then, becomes articulated by a mechanism in which students and the world meet in the digital in an epicyclic dynamic coupling. Chapter 7 will explore the structure (or hallmarks) of this coupling.

Chapter 7. The Hallmarks of the Experience

7.1. Introduction

In this Chapter, I present the findings regarding the micro phenomenological study. First, I show how I applied and adapted Valenzuela-Moguillansky and Vasquez-Rosati (2019) analysis procedure. Following this, I explain the particularities of the analysis and the resulting representations of the diachronic hallmarks both for the individual (single) and the general (group of) experiences collected. Then, I explain a methodological adjustment to the micro phenomenological original approach, specifically the use of dynamic thematic lines to bring MP and ME into diffractive dialogue. Finally, after considering these hallmarks, I use Rietveld's (2017) skilled intentionality framework (SIF) as a theoretical lens to unveil the students' entangled body readiness resulting from the dynamic described by the MP analysis. This serves to both validate and expand my findings by addressing the same phenomenon from multiple perspectives.

One of the main purposes of micro phenomenology (MP) is to help us re-discover the forgotten immediacy of the experience (Bitbol, 2024). However, the main problem with investigating people's experiences of past events is that we have a limited understanding of our experience and the process from which it arises (Petitmengin, 2017), mainly because our mind wanders and skips in between past, present, and future, rather than staying in the experience. We tend to interpret our experience based on narratives or preconceived ideas about what the experience should be, without paying much attention to how it happens. MP, however, dissipates this mind-wandering (Killingsworth & Gilbert, 2010) by focusing on the how, which helps reveal the unfolding of the experience within the particular landscape where it is anchored (Petitmengin, 2021), encouraging a focus on the specific details of the experience as to help gain a deeper understanding of the moment rather than relying on constructed narratives. During the unfolding, the landscape touches and permeates the subject (Julien, 2014) with its peculiar properties or, in Petitmengin's (2021) terms, its rhythms and forms of movement. Hence, as much as the purpose of Chapter 5 and 6 was to present the properties of that landscape, the purpose of the present chapter is to describe (1) the unfolding of the experience, and (2) how learner and landscape interact. To do so, two particular dimensions are pursued: the unfolding of the experience across time (diachronic structure), and the particular dynamics of a single moment. The diachronic structure presents and describes the moments or steps of the unfolding of the experience over time. On the other hand, a second level diachronic analysis of a single moment —the moment when students optimised their grip on the task by involving digital devices— identifies the dimensions present at a given moment.

7.2. Diachronic and Synchronic Hallmarks

As described in Section 3.5.2, the MP analysis design on which this research is based follows Valenzuela-Moguillansky and Vásquez-Rosati's (2019) set of 15 stages. The first nine stages refer to the analysis of a single experience, whilst the last six apply to a group of experiences. The present chapter presents the findings in two sections: 7.2.1 Specific Hallmarks explores individual, single experiences; and 7.2.2 Generic Hallmarks considers the group of experiences. Both of these sections include subsections describing the synchronic and diachronic hallmarks for each type. Details about the analysis were presented in Section 3.5, and practicalities about its application were addressed in sections 4.5 and 4.6; nevertheless, to facilitate the navigation of this chapter, Table 10 below is a summary of the main sections and subsections presenting the findings.

Table 10

Summary of the main section.

Section		Subsection		Description
7.1.1	Specific hallmarks (Hallmark of individual experiences)	7.1.1.1	Specific Diachronic Hallmarks	Hallmark of the single experience across time.
		7.1.1.2	~~Synchronic~~ Thematic Hallmark	Diffractive reading of MP and ME findings.
7.1.2	Generic hallmark	7.1.2.1	Generic Diachronic Hallmark	Hallmark of the group of experiences across time.

	(Hallmark of the group of experiences analysed)	7.1.2.2	Generic ~~Synchronic~~ Thematic Hallmark	Hallmark of a “moment” of the group of experiences.
7.2	Entangled ~~Skilled Intentionality~~ body readiness			Hallmark of the entangled experience

Two important caveats must be included here: (1) for the present study, no micro phenomenological synchronic analysis was applied; and (2) to preserve clarity, the language used to describe the overall structure of the MP analysis was kept (albeit modified by the strikethrough of the word synchronic). In other words, the analysis is micro phenomenological at the diachronic level, whilst at the synchronic level, a diffractive reading was applied to intersect and articulate the ME thematic analysis and the diachrony. This adaptation constitutes a contribution to the field of MP and was discussed and agreed upon with one of the creators of the analysis framework (Valenzuela-Molligasky, Personal Communication, 29th November 2024). This adaptation was motivated by the realisation that ME could provide a richer characterisation of this moment of the phenomenon. The application of the ME-inspired dynamic thematic lines allowed me to map the semantic data gathered from the ME analysis to the diachronic hallmark identified by MP, allowing for a more complete description of the phenomena whilst still preserving the integrity of the MP approach. In other words, the MP analysis described the process, and ME described the dynamic.

7.2.1. Specific Hallmarks

As explored in Section 4.6, one of the particular adaptations to Valenzuela-Moguillansky and Vasquez-Rosati’s (2019) approach was in relation to the preparation of the data. Therefore, after preparing the transcripts of the key participants and excluding all the satellite information, the remainder of the utterances were extracted and pasted onto a worksheet. Although Valenzuela-Moguillansky and Vasquez-Rosati (2019) suggest selecting the text in the form of utterances —as minimal linguistic units pragmatically interpreted—, to avoid loss of context, special attention was paid to conserve the integrity of the idea expressed, and when a series of utterances co-constructed a phenomenological perception, they were lifted as a single unit.

Figure 19 shows an example of the analysis of a single experience. Columns A and B (starting and finishing line) indicate the line from where the statements were lifted, and therefore capture the original chronology of the interview. Column C (moments) indicates the assigned number for the moments. These numbers were used to reorganise the statements according to the chronology of the experience. Column E (criteria) presents the reasons for grouping the statements. The words in bold in the statements supported the process of identifying phases and actions. Column F (UDI) identifies the incipient diachronic units. Columns G to J show the iteration of the processes.

Figure 19

Process of specific diachronic analysis.

	A	B	C	D	E	F	G	H	I	J
1					Iteration 1			Iteration 2		
2	Starting line number	Finishing line number	Moments	Statement	Criteria	UDI	Moments	Criteria	UDI2	UDI 3
3	59	59	1	We wrote a **draft** on our piece of paper before.	The statements speak about starting to write on paper	Drafting	1a		drafting	
4	70	71	1	So it's just **our own thinking**, just very **rough draft** and an idea of what we are going to write.			1a			
5	104	105	1	the paper one, it's mainly **just a draft, a quick draft,** just gathering the concept of it.			1a			
6	390	392	1	I would say starting on paper helps you see **what you know already**. Then you can see your starting point and then realize, Okay, we can improve on this when switching to a device.			1b		seeing what you know/don't know	
7	396	399	1	I guess with pen and paper, it's just obviously **just your mind.** So then from there on, we were all in silence and everything. So you're just focusing on that for just a solid hour. And you just **understand what you know**. And then **you also understand what you don't know** and how you can improve that.			1b	Drafting		Just your mind
8	404	407	1	from the first initial writing, **you can see the main idea.** That was the main thing that I was going for the idea and the trigger of the writing. Then from reading it back, I can understand, Okay, **I need to improve my tense. I need to add some more inventive words and definitely improve the language features** to make it more interesting.			1c		seeing what you need to improve	
9	119	120	2	I'd say I think we have a little bit more time because it's a bit **quicker to type** everything. If **we have an idea quickly, we can quickly type it.** Sometimes we can lose track of it if we're using paper.	The statements speak about the difference between writing and typing	Transcribing	2a		typing	
10	137	137	2	I'm just **able to process it a lot easier** than if I was to handwrite it.			2a			
11	59	61	2	And then from that piece of paper, we then **transcribed it onto our device**, and that's when **we started crafting** it and improving it step by step.			2b		transcribing	
12	80	81	2	we use our laptops to **rewrite the draft** again and just **make it even better** and improve it step by step so we can review it again and submit it.	The statements speak about transitioning to the device		2b	Transcribing		
13	141	144	2	I would say when I'm typing, it's just **a lot easier to write down things**. And then from there, compared to handwriting, it's a lot of pressure as well. Then **reading stuff properly** as well, because you have set fonts and you can read it properly because sometimes your handwriting might not be as good.			2b			Connecting online
14	300	302	3	the initial work was done on a **Google Doc,** so that was the first thing. Then the next thing was from Google getting synonyms for words, so just **connecting with Google,** getting different words, improving my vocabulary. Then the writing is a lot more interesting.		Connecting with online resources	3a		connecting	
15	310	310	3	I also **accessed former exemplars** as well of other students.			3a	Connecting with online resources		
16				Then also we have the **online resources** as well to just help us with **synonyms**,	The statements spoeak about how online aspects are used to help				using the resources	

7.2.1.1. Specific Diachronic Hallmarks

As mentioned in Section 3.5.1, each of the nine key participants took part in an MP interview of around 40-45 minutes. All participants were invited to share a description of their recorded lesson and also of a chosen experience where using digital devices was important for them. However, this design varied for two participants: Student 8's interview naturally drifted into a conversation about AI, mainly due to the scarcity of data on their main (recorded) experience; and Student 3 could not identify an experience where learning with devices was important to them.

The analysis considered only one of the two experiences discussed in the interviews for each student. Purposive sampling was used to select the focus interview (see Section 3.5.1 for details on the application of purposive sampling). Table 11 lists the topics of both the recorded and chosen experiences. The asterisk indicates which one was selected for analysis. It has to be noted that, although a single experience was selected for the MP analysis, all experiences were included in the ME analysis. The MP analysis of the transcriptions was iterative. All transcripts were subject to at least two iterations of the analysis, except for Student 1 for whom there were 3 iterations. Each experience was analysed independently as a single experience, and utterances were grouped to find patterns that help understand the hallmarks of the experience.

Table 11

Topics of the recorded and chosen experience.

Participant	Main experience (recorded)	Chosen experience (only evoked)
Student 1	Essay writing *	Coding
Student 2	Artist research	Essay writing *
Student 3	Note taking (Chemistry) *	None
Student 4	Note taking (Chemistry)	Mind map (Chemistry) *
Student 5	Logo Design (Art and Design) *	Remote Learning
Student 6	Photography Portfolio *	Assessment (Essay writing)
Student 7	Note Taking (Chemistry)*	E-Sports broadcasting
Student 8	History Research	AI use for learning *
Student 9	Logo Design (Art and Design) *	Essay Writing

Note. The asterisk (*) indicates the experience selected for MP analysis.

The diachronic analysis seeks to understand/describe evolution of the experience across the temporal axis. To that purpose, the utterances were reorganised, since the chronology of the interview is not necessarily the chronology of the experience. This involved considering each utterance in relation to the complete interview and assigning them a place ('moment') in the temporal evolution. The markers used for this purpose might be temporal or linguistic indicators of actions or events. In Figure 19, this process is evidenced by the allocated number in the moment-column. Successive iterations could modify these moments or add sub-phases to them. An auditable record of this process was kept to avoid overwriting the analysis. To do this, different columns in the analysis document are assigned to record each iteration. Once the moments were identified, the experience was re-organised according to those moments, and then specific diachronic units were identified by interrogating the data iteratively to make the grouping criteria explicit. These groups were then categorised, organised, and defined into phases, sub-phases, and sub-sub-phase. Finally, each unit was named by favouring the language used by the participant and avoiding choosing abstract ones. Table 12 shows the moments (or phases) identified for each student. As each experience was analysed and considered independently, at this stage of the analysis there was no significant alignment of the moments between the different experiences. Figure 19 shows the record of the evolution of this analysis (for a detailed explanation of this process, see Valenzuela-Moguillansky & Vasquez-Rosati, 2019).

The process of identification of moments (as I call the generic phases to avoid confusion), therefore, included the re-organisation of the utterances according to particular criteria. In the case of this analysis, I intended to understand the moments taking place when students and devices come together. The analysis, therefore, focused more on the action markers (verbs) than the chronological markers, therefore grouping the phases by processes and how they are organised in a temporal sequence of events. Table 12 shows the Specific Phases identified during the analysis of the individual experiences (for a complete representation of phases, sub-phases, and sub-sub phases, see Figure 19).

Table 12

Specific phases identified during the analysis of the individual experiences.

	Experience	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7
Student 1	Essay writing		Drafting	Transcribing	Connecting with online resources	Seeing the structure	Crafting		
Student 2	Essay writing		Looking through	Gaining ideas	Finding colours	Refining ideas	How things look and how colours can be used		
Student 3	Note-taking		Looking	Scribbling	Personalising	Importing	Going back and rearranging		
Student 4	Mind map	Redrawing	Colour coding	Grouping	Tidying	Looking back	Remembering	Understanding	
Student 5	Logo Design		Doing things manually	Being deliberate	Concentrating on the right place	Boop! Everything is done	The computer assumes what I want	Using both works better	Easier and more efficient
Student 6	Photography Portfolio		Experimenting	Physical work	Bringing out your device	Digitising physical work	More powerful than just a photo		
Student 7	Note Taking	Reading and understanding	Writing down notes	Keeping an eye on other things	Keeping an eye on what is taught and on the slides	Using and uncluttering the browser	Editing for neatness	Keeping tabs on my notes	
Student 8	AI use for learning		Connecting to the world	Using AI	Increasing my general knowledge				
Student 9	Logo Design	ideas before design	Plotting down on the screen	Skills and digital assistance	Mixing design features	Developing ideas	Do it on paper		

The specific moments identified during this level of analysis constitute the basis for the generic diachronic hallmark, which is the focus of the next section.

7.2.1.2. ~~Synchronic~~ Thematic Hallmark

As stated in the opening section of this chapter, the present study does not include a MP synchronic analysis. Instead, while somehow preserving the overall structure of MP analysis, it uses the synchronic step of analysis as an opportunity to diffractively articulate both MP and ME findings. As Valenzuela-Moguillansky and Vasquez-Rosati (2019) explained, in MP analysis:

> The synchronic analysis seeks to understand how the structure of the experience is characterised at a given moment. It can therefore refer to the identification and organization of the different aspects that make up the experience at a given time (in a phase or sub-phase). (p. 131)

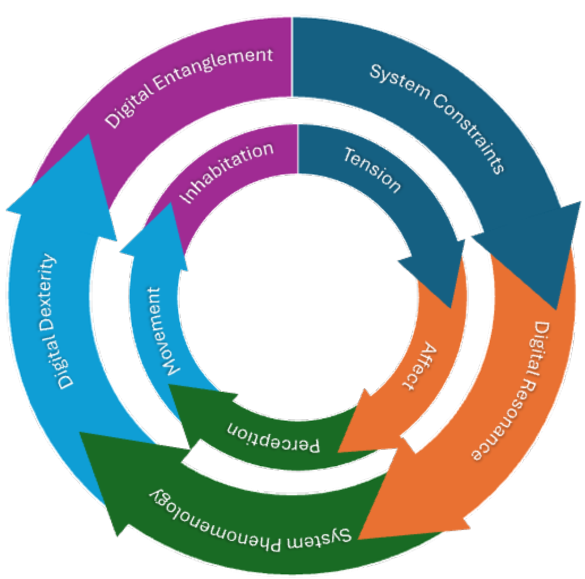
Thus, synchronic analysis is used to examine the experience at a specific point in time (a single moment), focusing on the relationships and structures present in that moment. It involves a detailed examination of a particular instant or snapshot of the experience and the simultaneous interplay of various elements (such as sensations, emotions, and thoughts). This approach provides a deep understanding of the complexity and interconnections within a single moment of experience. As they also pointed out, it is the research question, that provides the researcher with the guidelines about which moments and to what level of detail the synchronic analysis should be carried out (Valenzuela-Moguillansky & Vásquez-Rosati, 2019). For the purpose of this research, I intended to use MP analysis to (1) identify the moments of the experience; and (2) identify commonalities regarding how students connect with their devices. Therefore, the focus of the analysis of the single experiences was on identifying the diachronic hallmark rather than the single 'moment'.

Although this study does not use MP synchronic analysis, it adapts a strategy presented by Valenzuela-Moguillansky and Vasquez-Rosati (2019) as a way to bring MP and ME findings together. To organise the categories and visualise the synchronic structure of their MP analysis procedure, Valenzuela-Moguillansky and Vasquez-Rosati (2019) proposed two possible ways: dynamic lines or semantic networks. The use of dynamic lines serves to illustrate the evolution of actions or strategies used by the participants over time to perform the task. The semantic networks, on the other hand, help visualise the semantic relations between the categories identified in the analysis (2019, p. 134). For the purpose of this research, I adapted these two processes by bringing them into a single strategy: dynamic thematic lines. The purpose of these lines is to map out general directions, shifts, or patterns that contribute to understanding the dynamic nature of the experience (Pacheco & Fossa, 2023). Thus, using the main themes from the ME thematic analysis as dynamic thematic lines, they were applied to the experiences to help (1) visualise the evolution of the experience (dynamic lines); and (2) map the cascading resonance effects identified by the ME analysis and the progressive distribution of agency emerging from the MP analysis. I will be coming back to this process in more detail in the next section.

Two reasons compelled me to include in this chapter a specific ~~synchronic~~ section. First, to establish a link between this analysis and the one proposed by Valenzuela-Moguillansky and Vasquez-Rosati (2019); and, secondly, but perhaps most importantly, to indicate the shift of the focus of analysis. Although this level of my analysis does not align with the original proposal by Valenzuela-Moguillansky and Vasquez-Rosati (2019), it still focuses on the characterisation of structural attributes or modes of attention. Identifying the structural attributes meant redirecting the attention from the content of the experience to the experience of the content (Valenzuela-Moguillansky & Vasquez-Rosati, 2019, p. 132). That is to say, the structural criteria were made explicit by using the main themes identified in Chapter 6: (1) System Constraints; (2) Digital Resonance; (3) Digital Phenomenology; (4) Digital Dexterity; and (5) Digital Entanglement. In reading the findings diffractively, I identified that these themes could be associated with specific embodied dimensions: tension; affect; perception; movement; and inhabitation. Figure 20 shows the dynamic thematic lines and associated dimensions mirroring the cascading effect of the Digital Themes.

Figure 20

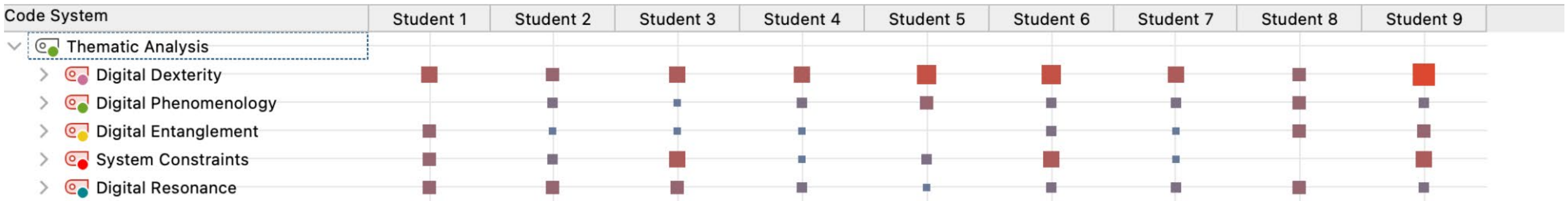
Dynamic thematic lines and associated dimensions mirroring the cascading effect of the Digital Themes.



The findings from the thematic narrative analysis have provided an alternative way to establish a dialogue between the two methodologies. Although, as I indicated at the start of this section, no MP synchronic analysis was carried out, the thematic analysis of the students' experiences identified a series of main themes. Since ME analysis used the totality of the experiences referred to by the students during the MPIs, using MAXQDA, I corroborated that said themes were present in the singular experiences analysed in the MP analysis. This presence is demonstrated in Table 13. The size and colour of the box relate to the frequency of the code in each particular experience. Red identifies the most occurrences, blue the least. The size of the box is proportional to the count of events of the particular code. These variables were not included in the analysis of the dynamic thematic lines. They are included here only as an illustration of the data gathered.

Table 13

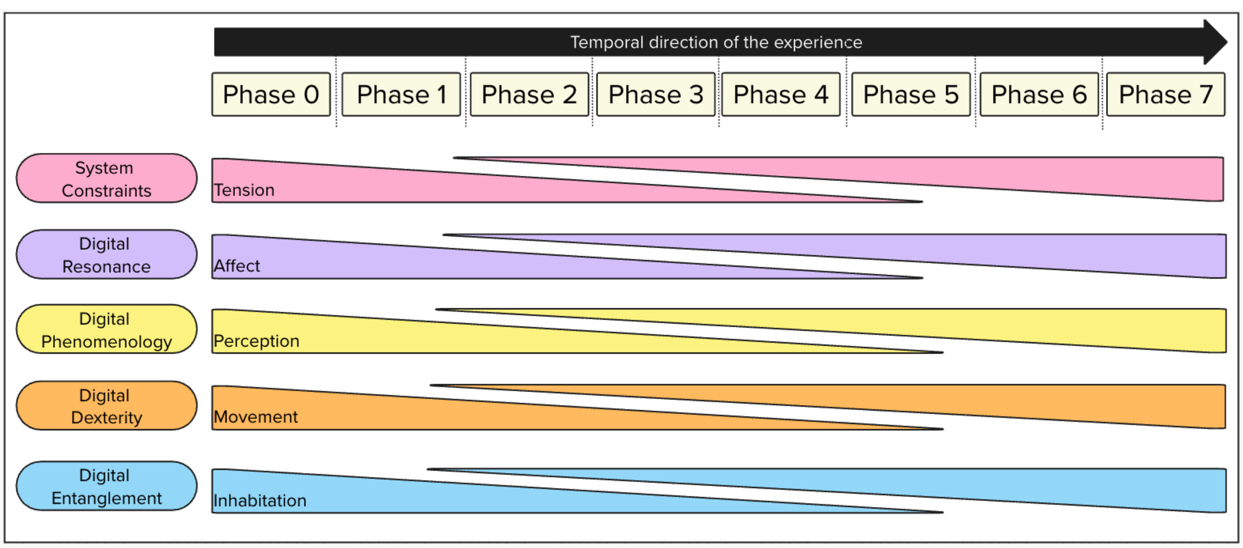
Dynamic Thematic lines distribution across the individual selected interviews.



Overlapping the dynamic thematic lines over each of the specific diachronic hallmarks seems to corroborate that both MP and ME analysis represent a progressive movement of integration between students and devices: while the MP findings identified the moments (phases), the ME seems to indicate the dynamic (a cascading resonance resulting in an incremental structural coupling as presented in Chapter 6). A simplified version of this process is presented in Figure 21. The coloured bands represent the dynamic thematic lines and their length was used to represent what phase of the experience they extend to, particularly considering that not all single experiences presented the same number of phases. How far each dynamic line extended was identified by contrasting the MP descriptions of the experience (moments) with the ME cascading ecological resonance described by the thematic analysis and weaving them together. This interpretative weaving was articulated around the question: How does the dynamic described in the themes (via the content of the codes inside it) relate to the dynamics described by the phases and subphases of the MP analysis? Despite differences in extensions, all experiences seemed to correlate with the same dynamic. Figure 21 presents the tool used to map the dynamic thematic lines over the phases of the experience. Section 7.2.2.3 will present the mapping over the general hallmark, as well as how it evolved.

Figure 21

Representation of the dynamic thematic lines including their embodied dimensions: tension; affect; perception; movement; and inhabitation.



7.2.2. Generic Hallmark

As mentioned in the opening section of this chapter, the singular hallmarks refer to the unique, individual features of a specific experience. These are the idiosyncratic elements of a particular person's experience. Singular structures capture the distinctiveness and specificity of an individual's lived experience. Generic Hallmarks, on the other hand, refer to the common, shared features of experiences across different individuals. These are the recurring patterns or themes that can be identified when comparing multiple individual experiences. These hallmarks, therefore, can help to better understand certain types of experiences, revealing commonalities that transcend individual differences. It involves identifying patterns and themes to construct a more generalised understanding of how certain experiences are typically organised. The next sections present these Generic Hallmarks.

7.2.2.1. Generic Diachronic Hallmark

Once the singular phases are identified, a process of aligning and grouping takes place, considering either (1) thematic content or type of action, or (2) internal time sequence or external time sequence. In the case of this study, the phases were grouped by similarity of thematic content. Figure 22 shows the aligned phases identified in the specific diachronic analysis, which were aligned by similarity of thematic content. The columns show the phases identified and the colouring indicates that a relationship among them was identified, yet at this point, the moments remain unnamed.

Figure 22

Aligned phases identified in the specific diachronic analysis.

Student 1			Drafting	Transcribing		Connecting with online resourses		Seeing the structure		Crafting			
Student 2		Looking through	Gaining ideas			Finding colours				Refining ideas			
Student 3		Looking		Scribbling						Personalising	Importing images	Going back and rearranging	
Student 4			Redrawing	Colour codding	Grouping	Tidying		Looking back				Remembering	Understandin g
Student 5	Doing things manually			Being deliberate	Concentrating on the right place	Boop! Everything is done		The computer assumes what I want		Using both works better			
Student 6			Experimenting	Physical work		Bringing out your device		Digitising physical work		More powerful than just a photo			
Student 7		Reading and understanding		Writing down notes		Keeping and eye on other things	Keeping and eye on what is taught and on the slides	Using and uncluttering browser	Editing for neatness			Keeping tabs on my notes	
Student 8						Connecting to the world				Using AI		Increasing my general knowledge	
Student 9	ideas before design			Plotting down on the screen		Skills and digital assistance		Mixing design features		Developping ideas			

Once the phases were aligned, a further process of abstraction took place to define the generic diachronic hallmark. At this point, the names of the phases of each single experience were carefully reviewed to name the generic moments. The overall naming resulted from a process of consideration of (1) the thematic connections between the phases; (2) the criteria by which they were grouped in the specific diachronic analysis; and (3) the revision of the utterances that constitute each of the phases. Finally, after considering all these aspects, the best name that synthesised them was selected to stabilise the diachronic structure. After those considerations, the generic diachronic hallmark moments were named as shown in Table 14.

Table 14

Generic diachronic moments and criteria.

Doxa	Contemplating the task	Drafting	Initial attempt	Connecting with the device	Optimising attempt	Distributed agency	Annexation
The statements speak about the cognitive state before engaging with the task	The statements speak about an initial surveillance of the task ahead or a recognition of the elements constituting the task	The statements speak about a first approach to the task, contextualised as a draft	The statements speak about the first proper exploration of affordances and plotting of the extended task	The statements speak about connecting with the digital device	The statements speak about a second, more in-depth engagement with the task while exploring the relevance of digital affordances. There is a realisation of a tension or disequilibrium in relation to the task at hand.	The statements speak about an entangled engagement with the task where the learner recognises a new field of affordances	The statements speak about an exit, and appropriation strategy after the resolution of the task.

Since these moments were defined collectively, identifying a single excerpt that summarises the entire moment can be challenging. Nevertheless, Table 15 presents a small selection of the statements included in the phases to illustrate the process.

Table 15

Examples of the students' statements for each of the generic moments.

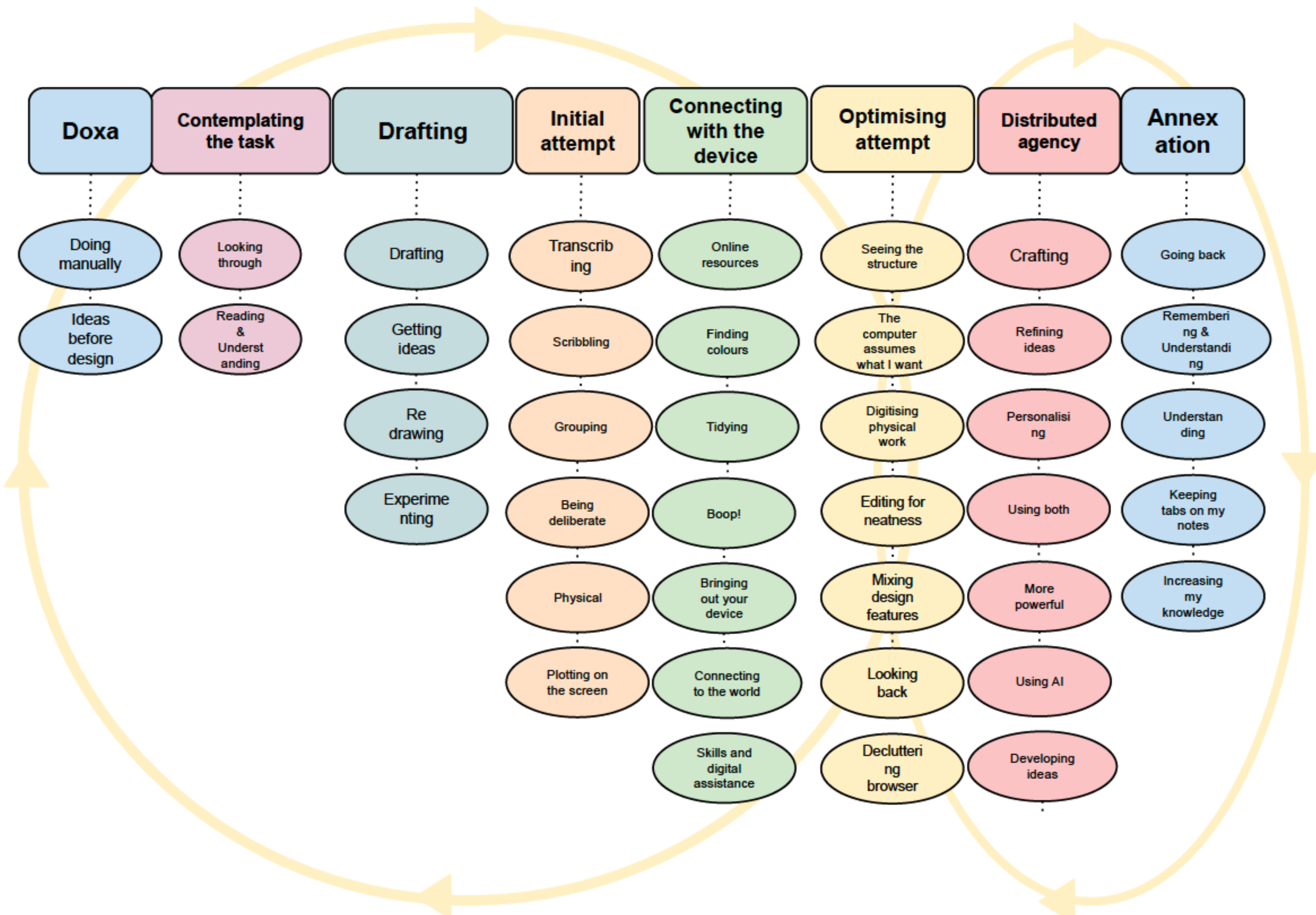
Moment	Sample Statement
Doxa	“the idea that you have behind the logo. It describes what your work is going to be about” (Student 9)
Contemplating the task	“my teacher provides all of the slideshows and notes that he uses on a Google site and I was on that Google site with the notes open, as he was explaining them” (Student 7)
Drafting	“Starting on paper helps you see what you know already. Then you can see your starting point and then realise, Okay, we can improve on this when switching to a device” (Student 1)
Initial Attempt	“The physical process is organic because you don't know what you're going to get” (Student 6)
Connecting with the device	“To find the colours, I was using my device; I was looking through all different colour palettes or colours that work together um and I can't actually do that on paper because I don't have every single colour in the world” (Student 2)
Optimising Attempt	“But since I redrew it on my iPad, I could look at it easier and look back at it” (Student 9) “[The computer] makes the process faster. Because it's a visual thing. It has to look clean. It has to look how I want it to. But the computer doesn't know exactly what I want. It can only assume” (Student 5)
Distributed agency	“[I use AI if] I just want to quickly summarise it, read a summary maybe. I want to see it from a different perspective. I can just put it in AI. It'll just throw some things around so I see it in a different perspective” (Student 8). “I think it's a limbo. I think it's both. And I wouldn’t categorise it. It’s digital-physical because it's purely both. The final result is digital, but the process wasn't” (Student 6)

Annexation	“The good thing about writing on the iPad is you can go back and rearrange stuff and easily remove or add stuff. If you got it in a book with a pen, you can't really move stuff around. So it lets me make more tidy notes, I guess, and then it's easier to revise from them”. (Student 2)

Figure 23 shows the final representation of the generic diachronic hallmark (including moments and subphases). The confluence of the yellow arrows in the Optimising Attempt phase signals an interesting aspect of this hallmark. The subphases constituting the Optimising Attempt moment seem to mirror the diachrony of the experience as a whole (in a fractal structure of sorts). Therefore, this particular moment was the object of a second-level diachronic analysis (which is discussed in Section 7.2.2.3). What made this mirroring particularly interesting was that this effect was also observed during a pilot study (Rodriguez, 2025). During the methodological pilot, I tried MP as a way to study the use of digital devices to accomplish cognitive tasks. To do so, I interviewed and analysed the experiences of users of Wordle (a digital word puzzle). The findings show the existence of a fractal effect in the experience, which includes “[f]ractal patterns [that] possess self-similar components that repeat at varying size scales” (Robles et al., 2021, p. 1). Some of the sub-phases (and the order in which they occur) held some resemblance to the event phases and their sequencing. The same fractal structuring seemed to be occurring with the students’ experience, which might indicate the dynamic articulating the optimising of the grip on the task.

Figure 23

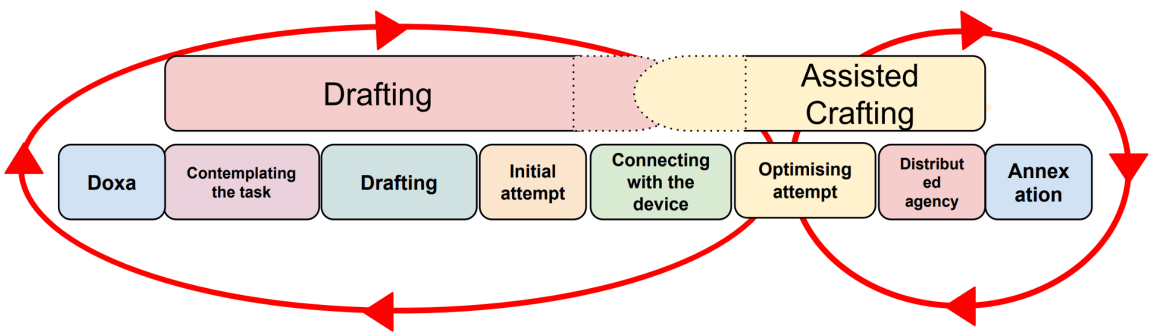
Final representation of the generic diachronic hallmark (including moments and subphases).



Once revised in light of the initial reflections from the pilot, the final generic diachronic hallmark was generated. Figure 24 shows the hallmark which includes the moments identified during the generic diachronic analysis and an overlay of the overarching moments identified during the pilots and confirmed during the MPI interviews. The red arrows point towards the phase identified as the focus of the second-level diachronic analysis. As illustrated, the fractal moment seemed to be taking place as students transitioned between drafting and crafting.

Figure 24

Revised generic diachronic hallmark including the diachronic moments and the main moments.



7.2.2.2. Generic ~~Synchronic~~ Thematic Hallmark

Understanding the hallmark of a single moment is essential to identify not the content of the experience, but how the participants experience the content (Valenzuela-Moguillansky & Vasquez-Rosati, 2019, p. 132). Micro phenomenological analysis, according to Petitmengin et al., (2018), consists of

> 1) [...] identifying in structural statements minimal units of meaning, [...] and 2) [...] abstracting - in the etymological sense of the term: 'pull-out' (ab-strahere) - from these minimal structural statements, more and more generic descriptive categories, on the synchronic and on the diachronic levels, through a number of abstraction operations. (p. 704)

However, as they point out, "[the] work of micro-description of the experience of abstracting [. . .] is one of the ongoing projects of micro phenomenology" (Petitmengin et al., 2018, p. 706). To this point, this research intends to offer an alternative approach to identifying "the aspects that make up the experience at a given time" (Valenzuela-Moguillansky & Vasquez-Rosati, 2019, p. 131), by generating this process of abstraction and identification of the synchronic hallmarks by micro ethnographic narrative thematic analysis (therefore offering, to the best of my understanding, a methodological contribution to the field of micro phenomenology). In this way, the application of the dynamic thematic lines constitutes the hinge where the two methodologies (micro phenomenology and micro ethnography) interact, as per the approach taken here.

Valenzuela-Moguillansky and Vasquez-Rosati (2019) advise that to identify semantic networks, the researcher must ask themselves “How do the categories that have been identified relate to one another? Or, what are the operations of abstraction that relate to these categories?” (p. 134). My proposed dynamic thematic lines emerged too from the semantic networks identified by interactive processes of interrogation and abstraction, but they come from the ME thematic coding. This allowed me to identify how the different strategies relate to each other intra and across experiences. As Petitmengin et al. (2018) pointed out, “the synchronic analysis consists in identifying the architecture or topography of this landscape [the experience]” (p. 701), by, as stated above, “abstracting [. . .] from these minimal structural statements, more and more generic descriptive categories” (p. 704). By bringing both methodologies together, this analysis makes evident the topology of the experience and its correlations, and a contribution in relation to alternative ways to make this abstraction.

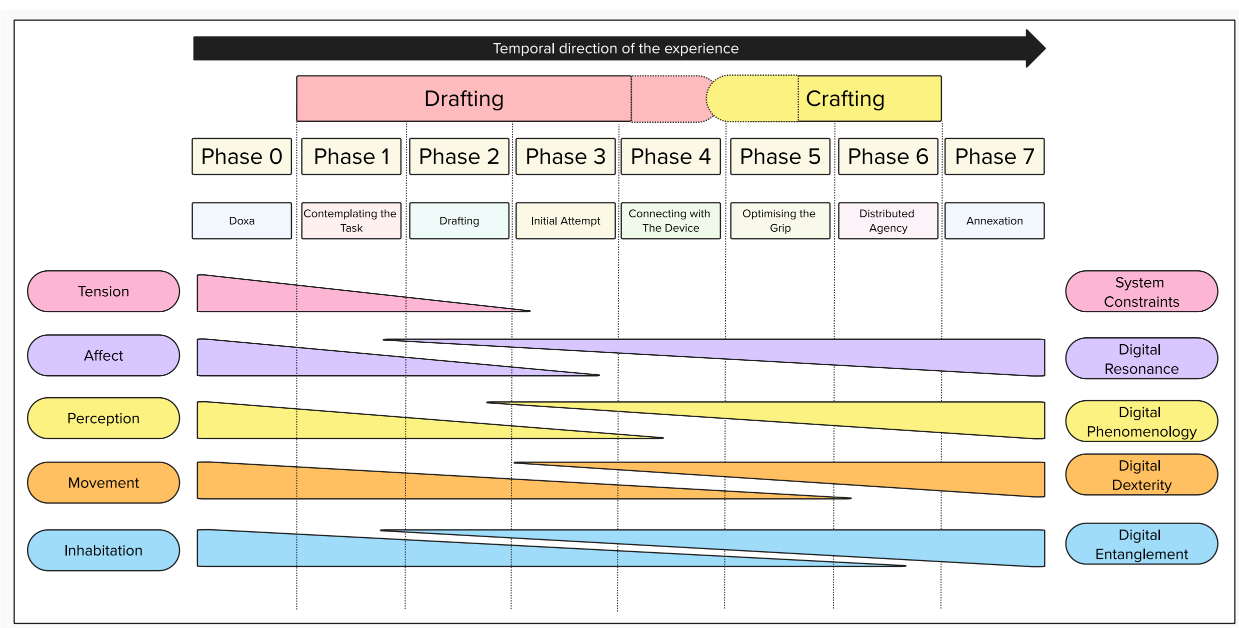
The application of these thematic dynamic lines to the diachronic hallmark created a dialogue, not only between the moments and the qualities of the experience, but also between the two methodologies used for this study. This is of particular importance as a way to corroborate the validity of the analysis (since both sets of results can be plotted on one another), but also because it creates an inter-methodological conversation at a deeper level. The MP approach argues that preconceptions that we have about our experiences distort them. This transversal articulation of the methodologies seems to establish links between the embodied experience of learning with digital devices (the MP focus) and the emergence of the actor-narratives (the focus of ME) that impact that experience. Furthermore, the overlapping of the phases and the dynamic lines were found to present an initial dynamic of the experience. In it, there seems to be an increasing level of entanglement between students and their digital devices for the purpose of optimising their grip on the learning task. Once students survey the task, they shift their attention to their devices, primarily motivated by skill and cognitive resonance with the affordances of their devices. Student 6 referred to this entangled expansion of their grip on the task when they stated “I feel digital and using a laptop almost extends what you can do” (Student 6, 224). Another clear example of this was a statement by Student 1:

> I think I just felt a bit more connected [to my work] with the device. I was able to think of my writing and actually realised, Oh, I can definitely improve this. Swapped some things around to make it more intriguing for the audience. (Student 1, 154)

After referring to connecting to the device, they said they were "able to think" as if they were actually thinking ‘with’ the device. They are now connected and aware of the device's affordances and can craft the text. The articulation seems to be in the fact that they say "I think" rather than “now I can do x or y”. They are not just instrumentalising the device, but seem to be thinking with it, where the device, rather than being a tool, seems to be part of their cognitive process. In this resonating context, the digital becomes (1) a structure of perception, (2) a structure of action, and (3) a place of encounter. This digital phenomenology becomes the place where the world and the body meet, developing a particular form of digital dexterity, resulting in an enculturated body that entangles with the digital in order to optimise the grip on the task. Figure 25 shows the relationship between moments and dynamic thematic lines. It maps the correlation between the moments of the experience and the different dynamic of transition within the dimensions of the experience towards a state of digital entanglement.

Figure 25

Dynamic thematic lines mapping the transition of the dimensions of the experience towards the Digital Entanglement.



An immediate criticism of this representation, if the reader is familiar with micro phenomenological analysis, would be that “[t]he objective of the micro phenomenological interview is to obtain detailed descriptions of single experiences, focusing on the procedural dimension and from an embodied perspective” (Valenzuela-Moguillansky & Vásquez-Rosati, 2019, p. 124). Although this section presented some aspect of embodied dimensions (in the form of the thematic dynamic lines), I explore the question of embodiment later in Section 7.3., and in more detail in Chapter 8 when discussing the notions of digital dexterity and the digital as a structure of perception and action. The next section will focus in a second-level diachronic exploration, but this time of a single moment (Optimising the Grip) in order to further describe how the digital becomes a topography where the body and the world converge. That is to say, the particular felt-landscape on which the experiences of the students were anchored (Petitmengin, 2019).

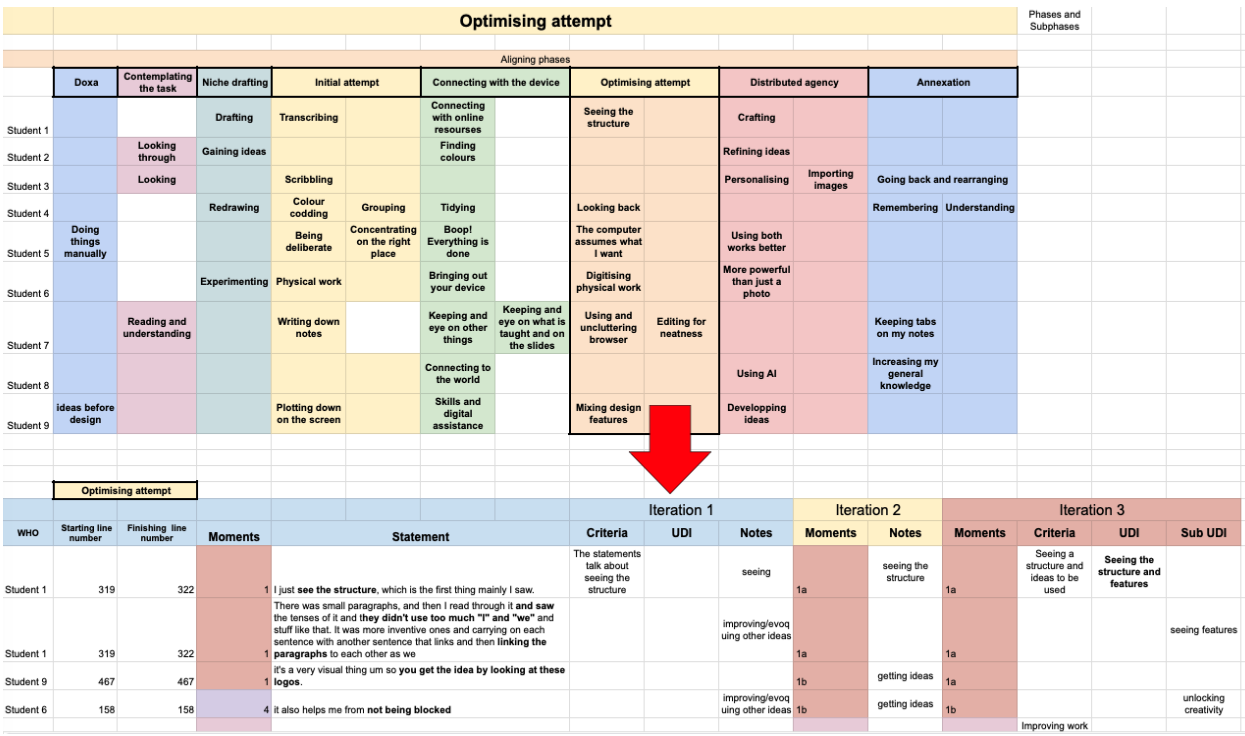
7.2.2.3. Second-Level Diachronic Analysis

The purpose of this study is to describe how students and devices not only come together but also how they stay together. The previous section described the unfolding of the experience over time. This section looks into what I see as the single moment of articulation in which devices and students engage in an entanglement. As indicated in the previous section, from the analysis of the utterances, phases, and sub-phases, it transpired that there were some similarities between the general diachronic hallmarks and the diachrony of a single moment (Optimising Attempt). Moreover, in the current study, the stabilising point in the connection between the student and their device was identified to be not the Connecting with the Device moment, but the emergence of goal-directedness during the Optimising Attempt. During the analysis of the sub-phases, a picture started to emerge: whereas the Connecting with the Device moment presents itself as a utilitarian, functional moment, in the Optimising Attempt moment students and devices gear towards action. Furthermore, that preparation for readiness implied looking back (towards the initial moments) and forward (towards the final moments) in a kind of repositioning of their grip on the task (which could explain the fractal effect). Therefore, the Optimising Attempt phase was selected as the target for second-level diachronic analysis. Moreover, this phase seems to articulate the movement towards the last two structural attributes or modes of attention (digital dexterity and digital entanglement).

The second-level diachronic analysis was very similar to that of the singular diachronic hallmark, but instead of working with the utterances from a single participant, the analysis included all the utterances by all the participants for that single moment. That is, all the utterances from all the participants referring to the Optimising Attempt moment were lifted and iteratively analysed, as depicted in Figure 26.

Figure 26

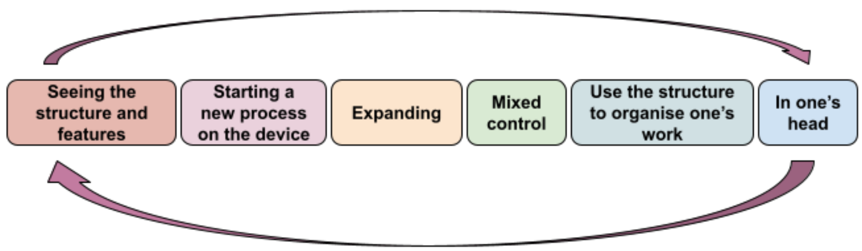
Generic synchronic analysis.



After three iterations of analysis, the representation itself went through three further iterations. Figure 27 shows the second iteration, with the six moments identified. The thematic similarities of the 14 original sub-phases were taken into consideration when naming the moments. Seeing the structure and features mirrors Doxa and Contemplating the Task; Starting a New Process on The Device mirrors Drafting and Initial Attempt; Expanding mirrors Connecting with the Device; Mixed Control relates to Optimising Attempt; and Use the Structures to Organise One's Work relates to both Optimising Attempt and Distributed agency. Finally, In One's Head is again an exit strategy and the resetting of a starting point (the arrows indicate the circularity of the incorporation of the resolution strategies into the next iteration).

Figure 27

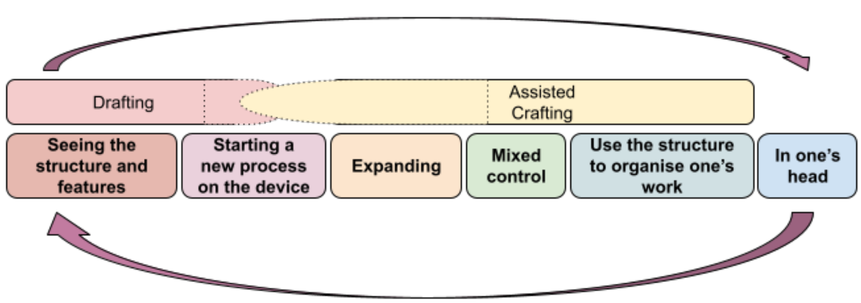
Second iteration of the second-level diachronic analysis.



The final iteration of the second-level diachronic analysis representation was compared with the findings from the revised generic diachronic hallmark (Figure 23). During this of this comparison it was established that the diachronic overarching moments of Drafting and Assisted Crafting were still evident, although they seem to start at an earlier step than on the general hallmark, as presented in Figure 28.

Figure 28

The third iteration of the generic diachronic hallmark phases, showing the overarching moments of Drafting and Crafting.



At this point, it looked as if the analysis was complete. In some ways, this could be considered a complete analysis that answers the research question of what is the nature of the entanglement between secondary school students and their devices. It could be said that it is a process that includes eight moments, and it is characterised by a progressive distribution of agency motivated by the optimisation of the attempt at solving a task. An experience that showed a fractal relation of sorts at the level of the connection between students and their devices. However, at this point, two issues were made evident to me. First, as it will be presented in Section 7.3, although an essential aspect of MP is a focus on the procedural dimension (which I have presented), the embodied perspective seemed to be missing. It was this lack of presence of the body that led me to the second issue. The dynamic I had just described was not presenting the body directly but eliciting it: the body (or the embodied perspective) was located in the interstices (gaps) of this dynamic described by the MP analysis and the topography of the MP findings. In order for the full dimension of the body to emerge, it was necessary to look at embodied dynamics not as property of the described entanglement, but as a result of the relationship between this particular topography and the students. Yet another theoretical lens will be necessary to make it evident. The last section of this chapter looks into this entangled body readiness.

7.3. Entangled ~~Skilled Intentionality~~ Body Readiness

The previous sections, looking into how students and devices come and stay together, presented how the intersection of ME and MP analysis portrays both the dynamic of the encounter and the topography of that encounter. However, a further theoretical lens is needed to understand the intricate dynamic governing the emergence of Digital Entanglement. The next sections present this theoretical undertaking, connecting the findings of this study with specific perspectives of affordances. The next paragraphs present some theoretical consideration, before bringing them together in Section 7.3.1.

Gibson argued that “[t]he affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill” (Gibson, 1977, p. 120). Such affordances imply some form of complementarity between the animal and the environment. They are not just physical properties, but they have to be considered relative to the animal. An affordance is neither an objective property nor a subjective property, but cuts across this dichotomy. That is to say, they are both a fact of the environment and one of the behaviour, pointing in both ways. This environment also includes the cultural environment. Far from dualistic, in this view, “[t]here is only one world, however diverse, and all animals live in it, although we human animals have altered it to suit ourselves” (p. 122), creating in the process new forms of affordances.

Although there have been a few attempts to develop a coherent theory of affordances, most post-Gibsoninan attempts to set out an ontology of affordances tend to see affordances as properties of the environment (Chemero, 2003, p. 182), even if they agree that they are also animal-relative, they do not seem to agree on relative to what. Affordances, therefore, are not properties or features of the environment alone, but features of whole situations (Chemero, 2003), they belong to the animal–environment systems. Perceiving affordances, thus, means seeing that a situation allows a certain activity. Thus, "the environmental relata in affordances must be features, not properties" (Chemero, 2003, p. 186); they are a relation between the abilities of an animal and some feature of the situation rather than a property of the situation: a feature affords effectiveness whilst a property demands it. This issue becomes critical when seen from the perspective of what Merleau-Ponty (1962) called the maximal grip. For Merleau-Ponty, "[t]he body is our general means of having a world" (p. 147), and perception, therefore, can be understood as its active deployment in that world. Rietveld (2014) understands this orientation of the body toward the environment as "the tendency toward an optimal grip, as the tendency toward an optimal metastable attunement to the dynamics of the environment" (p. 10).

7.3.1. Activating Skilled Intentionality

Rietveld (2014; 2008; 2017; 2013; 2018; 2017) understood affordance-responsiveness as a central feature of everyday skilful activity. He coined the term *Skilled Intentionality* to refer to the selective engagement with multiple affordances simultaneously in a concrete situation (Rietveld, 2018). He argued that the acquisition of human abilities reflects a history of interactions with socio-cultural practices that is achieved by responding to affordances in a context-sensitive way. His Skilled Intentionality Framework (SIF) defines affordances as, "a relation between (a) an aspect of the (socio-material) environment and (b) an ability available in a 'form of life'" (Rietveld et al., 2018, p. 45). His term *form of life* refers to coordinated patterns of behaviours amongst individuals and can be applied both to a species or a socio-cultural practice (from speakers of a particular language to builders, or architects). Situated normativity (or practice-based normativity) is crucial to understanding higher cognitive processes, because abilities are both embedded in and acquired through our participation in a socio-cultural practice (Rietveld, 2018). Skilled individuals, therefore, are oriented towards an optimal grip on the landscape of affordances available to them. These place-affordances (different aspects of the socio-material environment) generate patterns of action readiness in the individual towards a skilled grip on the situation. Applying Rietveld's SIF to the MP generic synchronic hallmark of the experience results in the representation where the transition from Crafting to Drafting is marked by the access into a situation whose features allow for a movement from a landscape of affordances to a field of affordances, by a process of selective openness resulting from the historicity of encounters with that environment. That is to say, it is a relational appeal to the abilities of the students by some feature of the situation. The next section discusses this in more depth.

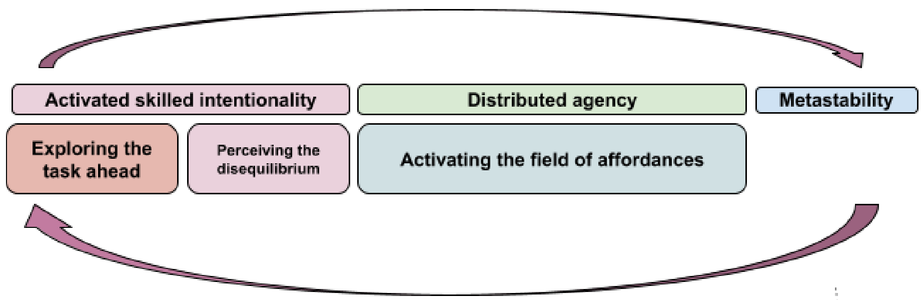
7.4. Distributing Agency

Rietveld’s (2017) SIF uses two different notions in relation to how the affordances present themselves to the individual. The landscape of affordances refers to “the many affordances that are available in a certain form of life or ecological niche” (p. 547), whereas the “field of affordances” is “the relevant field of affordances as lived by a particular individual in a particular situation” (p. 547). The field of affordances can also be understood as a field of solicitations in the sense that they solicit the individual’s skilled action. In order to activate the field of affordances, the life form not only needs to be located in a particular situation but must perceive the disequilibrium (in the sense that the experience deviates from the optimal relationship with the environment). Moreover, “sub-optimality in the ‘person-landscape of affordances’ relationship is experienced as a tension” (Rietveld, 2017, p. 549), similar to the one perceived by the students when they explore the task ahead.

In the original representation of the second-level generic diachronic hallmark (Figure 23), two levels of engagement with the task can be recognised: (1) the Initial Attempt (to solve the task without the connection to the device) and, (2) the Optimised Attempt (in which the learner and the device are entangled). This process demands not only the acknowledgement of a tension or disequilibrium between the current state and the optimal state but also that of a disequilibrium in the transition from a landscape of affordances to a field of affordances by a selective openness to affordances. This transition from the landscape to the field of affordances requires the individual to identify a disequilibrium (as that experienced by the students in the resolution of a task) and to be selectively open (to direct their intentionality) towards a particular set of affordances available to them. Those affordances (understood as a feature of the situation) emerge via the process of distributed agency. The distribution of agency is the product of the learners' abilities reflected in a history of interactions with their devices and socio-material practices. It thus results from (1) the identification of a disequilibrium; (2) a selective openness motivated by a need to (3) obtain metastability; and (4) a historicity of entanglement, in which students, digital devices, and the immediate topography drift and evolve together in dynamic coupling dance. Figure 29 presents the hallmark of the moment optimised their grip on the task through the lens of SIP.

Figure 29

Rietveld SIP applied to the moment students optimised their grip on the task (second-level generic diachronic hallmark).



Rietveld et al., (2018) defined metastability as “a property of coupled dynamical systems in which over time the system’s tendency to integrate and segregate coexist” (p. 54). Achieving this requires the individual to react to the landscape of affordance via selective discontent (a result of the history of engagements between the individual and the socio-material practice). This perceived dis-attunedness results in a selective openness towards a metastable attractor and a self-organising process towards it. In this process, learners distribute agency according to levels of solicitation between themselves and the devices by identifying how to switch between behavioural patterns in order to facilitate what Rietveld calls a “Hypergrip” (a zone that offers a wide range of action opportunities and the possibility to flexibly switch between patterns of behaviour). The distribution of agency becomes the strategy by which the abilities of the (entangled) student and the features of the situation come together.

7.5. The Nature of the Entanglement

This chapter answers the first research question of this study, “What is the nature of the entanglement between secondary school learners and their digital devices?”. From the first attempts at this (Rodriguez, 2025), an incipient structure of moments started to emerge: a first moment of Drafting followed by a second instance of Crafting. The former was characterised by an organic, free-style approach; quite often unassisted and manual, where initial ideas without concern for exactitude or coherence were in one way or another concatenated. The latter was more often than not assisted (as in digitally assisted). Although this Crafting moment was where the artefacts would be crafted into their optimal shape, it was the knowledge of its assisted nature that allowed the students to creatively and unconcernedly draft their ideas without disquiet about how to bring them into existence. Both moments were entangled. Therefore, the hallmark of the entanglement between the secondary school participants in the present study and their digital devices can be defined as one of initial solo Drafting, followed by assisted Crafting. The transition of these moments is defined by an intentionality to optimise the grip on the task. The point of articulation between one and the other is, using Rietveld's (2018) terminology, the perception of the disequilibrium between the initial state of drafting and the goal state of crafting. In Student 2's words:

> The draft is the basic, so it's just everything that you want to say. But then the final is everything you want to say how you want to say it. So the draft is missing the how you want to say it. (Student 2, 448)

This directed discontent allowed for a selective embodied openness to affordances, which in turn was articulated by distributing agency between the learner and the device. In this regard, Student 5 stated the following:

> Based on what you tell it, [the computer] can only assume what you want. (Student 5, 390)

And that distributed agency allows the students to think with their devices. It becomes the strategy to enable the abilities of the (entangled) student and the features of the situation to come together. As exemplified by Student 1, when they argue that they could think 'better' about his work when they were connected to their device, therefore being able to switch between the landscape and the field of affordances.

> I think I just felt a bit more connected [to my work] with the device. I was able to think of my writing and actually realised, Oh, I can definitely improve this. (Student 1, 214)

This section of the research described the hallmarks of the experience of learning with digital devices as it unfolds on the temporal dimension but also the particularities of that encounter in a singular moment. Moreover, the micro phenomenological focus on the procedural dimension from an embodied perspective allowed me to scrutinise the role of embodiment in this process, and to highlight how the enculturation of the body by the digital gives rise to a particular form of dexterity in a digital topography of encounter (between the body and the world). In this entangled dynamic, skilled intentionality (Rietveld, 2017) becomes **entangled body readiness**.

7.6. Summary

In this chapter, I presented how the present MP analysis is based on the process of analysis proposed by Valenzuela-Moguillansky and Vasquez-Rosati (2021). Then, I discussed the use of the term hallmark, rather than structure, which was chosen to preserve the dynamic nature of the experience. After presenting the diachronic hallmarks, both of the singular and the group of experiences, I introduced a methodological contribution of this research to the field of micro phenomenology by establishing a dialogue between the two methodologies to identify the dynamic thematic lines. This contribution allowed me to interpret the MP results using a ME lens, and vice versa in a diffractive dynamic. Finally, after acknowledging the lack of embodied dynamics in the description of the hallmark of the experience, I presented how another diffractive reading (this time between the identified hallmarks and Rietveld's (2017) Skilled Intentionality Framework) evidences the embodied dynamics as an entangled body readiness, as a way to both confirm and expand the proposed understanding of the experience.

Chapter 8. Discussion

8. Summary of Findings and Key Ideas

The title of the present study, Digital Entanglement, reflects that, in order to provide an accurate description of the phenomena at stake, the foundational theories of this inquiry must be considered entangled. It is not possible to discuss current aspects of education or schooling without referring to cognition, technology, and to how our body and mind relate to these domains. Inspired by the ethnographic work of Fernwick (2015), I wanted to understand how students and devices come (and stay) together. This required understanding what the process of coming together looked like (the micro phenomenological part of this inquiry) and figuring out why and how they stayed together (the micro ethnographic part of this inquiry).

The first part of the question is answered by the micro phenomenological inquiry. The MP analysis showed that students engage in a process of progressive entanglement with their devices for the purpose of completing a task. Two overarching main moments seem to organise this dynamic: an initial solo Drafting moment, followed by an assisted Crafting one. This structure seemed to be fractal, present both at the general diachronic level (moments) and within the single moment of connection with the devices. Furthermore, overlapping this ever-increasing distribution of agency from solo Drafting to assisted Crafting –at the moment students connect with their devices– with Rietveld's (2017) optimal grip on the task and skill intentionality framework, made evident that students were reporting a process of (1) acquisition and (2) application of patterns of body-readiness.

To answer to the second part of the question (staying together) it was necessary to describe the process of inception of students' body readiness. This was demonstrated via the micro ethnographic findings, which can be differentiated into three categories: (1) the identification of Digital Ontophany in the students' stories; (2) a tentative definition of the properties of digital artefacts; and (3) the identification of a dynamic of navigation of tension between different approaches to solve a task, around which students select a version of their performative identities: The Tale of Two Selves.

In relation to (1), verifying the presence of Vial's dimensions for the digital in the students' interviews opened the door to recognising a process of digital ontophany (a process where things come into reality saturated with digital dimensions). In this digital environment, artefacts present specific properties that impact both on how digital artefacts are born and can be manipulated, but also on the embodied responses needed to do so. A set of triads identified in the way that Vial's (2019) dimension relate to each other was used to (2) describe the properties of digital artefacts: explorable, constructible and nomadic. In turn, this particular malleability was one of the elements present in the (3) students' stories in relation to the ways in which they navigated and resolved the tension between analogue and digital practices. A constitutive factor of students and devices staying together relies on particular forms of resonance, both embodied and cognitive. The digital becomes an overarching structure that brings together the world and enacts the 'I' (as a new structure of perception and action, see Chapter 6).

This ecological resonance can be seen as the master narrative of the student stories: digital ontophany creates a niche in which students resonate with their devices at affective, cognitive, and skill level, which leads to them remaining in this particular phenomenology. In turn, this persistence creates correspondences that express themselves in the form of digital dexterity (articulation of body responsiveness to the environment). Responsiveness to the world is distributed between the students and their devices, since is this distribution of agency that becomes the strategy by which the abilities of the (entangled) student and the features of the situation can come together. The digital then becomes a space where the body and the world meet to solve problems.

This discussion chapter critically engages with the existing theoretical perspectives in an intertwining dynamic with the findings of this study. This critical reading suggests that digital ontophany creates a series of progressive entanglements that culminate with the digital emerging as a place where the world and the body meet. Digital Entanglement, although reproducing the general strategies of material engagement (Malafouris, 2013) and correspondence (Ingold, 2013), engages in a unique ontophanic (Vial, 2019) resonance (Raja, 2018, 2021) that impacts cognition. Bringing together arguments from anthropology, psychology, and my findings suggests that digital Entanglement is a change of *locus*, but not one of *modus* in relation to generalised dynamics of embodiment and material engagement. That is to say, we are *in* the world and *of* the world that we inhabit. This newly found locality, I suggest, requires an expanded understanding of enaction, embodiment, and engagement with the world, since digital artefacts (objects and/or cognitive devices that emerge out of human manipulation by digital means) are governed by a unique set of properties (explorability, constructability, and nomadicity) rather than those of physics (Causal Closure of Physics, CCP).

A contribution of the present study resides in this diffractive reading that displaces certain theoretical frameworks (like those of material engagement, enculturation, correspondence and dwelling), repositioning them in a way that enables new light into the explanation of the digital phenomena. Its main contribution is the concept of Digital Entanglement (see subsection 8.1) which conceptualises the nature of the Entanglement between students and their digital devices. This chapter starts by defining the parameters of Digital Entanglement, which encapsulates how, although Digital Entanglement reproduces strategies of material Entanglement, the particularities of the digital make this engagement unique. In the same way that Archaeology reconstructs social practices by examining the properties of discovered artefacts and using evidence to draw inferences about people's material entanglement with these objects, Digital Entanglement proposes that digital artefacts possess unique properties that permeate entangled dynamics. These properties redefine the conditions of possibility, particularly regarding the role of the body in this encounter.

This inquiry has been organised around two central research questions: (1) What is the nature of the entanglement of students and their devices?; and (2) what are the implications of this entanglement for learning in secondary schools? Therefore, this discussion chapter consists of two sections, each answering one of the research questions. In turn, the subsections follow a structure that mirrors the threads introduced in the literature review (Chapter 2), but offer a more in-depth critical analysis, while intertwining and redirecting the attention towards the findings of this study. This weaving offers a pragmatic conversation positioned in the overlapping space of technology, education, and embodiment in the classroom. Although the discussion weaves together several aspects of the literature reviewed in Chapter 2, the most important thread is the diffractive conversation between my findings and existing theories.

The discussion of the first question opens with the conceptualisation of Digital Entanglement (Subsection 8.1.1). As presented in Chapter 5, Digital Entanglement it is characterised by a reticular structure - a network of interconnected platforms. Subsection 8.2.2 sets a philosophical argument in which onto-epistemology (Barad, 2007) is used as a way to describe how the reticularly-interconnected student become not only a being-*in*-the-world but a being-*of*-the-world. That is to say, the student embodies particular correspondences (Ingold, 2013) with the world they inhabit. This correspondence, I argue, is bidirectional because it is entangled in a dynamic coupling (Maturana & Varela, 1980; Varela et al., 1991/2017).

However, understanding this entanglement as an onto-epistemological encounter requires a framework that is not bound by the Cartesian conceptualisation of mind and world as separate entities. Continuing with the weaving of theories, Subsection 8.2.3 brings together several theories to present a coherent proposal where there is no inherent separation between the mind and the world. To do that, I intertwine the Extended Mind Theory (Clark & Chalmers, 1998), and Perception as Action (Merleau-Ponty, 1962) in the context of a monist philosophy (Spinoza, 1677/2020). To bring this framework into the context of the present study, I use Stalder's (2018) digital condition to explain how this reticularity truly structures the way in which students construct and experience their identities.

The discussion around the first question closes with Subsection 8.2.4, which brings together the notion of enculturation (Menary & Gillett, 2022) and integrated perspectives of dynamic interaction between cultural contexts and individual mental experiences (Kirmayer, 2020). Here, I make the main argument of this study: Being in the world as a digitally entangled being redefines all possibilities in the world (how things appear), creating specific forms of body-readiness (digital dexterity) that enculturate both cognitive and embodied practices. Digital Entanglement requires students not only to think with digital artefacts but as one too, since the digital seems to emerge as the space where the world and the "I" meet.

The second part of this discussion chapter focuses on the second research question: What are the implications of this entanglement for learning in secondary schools? (Subsection 8.3.1). This discussion brings together different theories of deep learning to argue that, in the light of the findings of the present study, Entangled Body Readiness (Section 7.3) —based on Rietveld (2017) Skill Intentionality Framework (SIF)— should be prioritised as a model of deep-learning-in action in the sense that entangled practices create entangled body readiness. Finally, Subsection 8.3.2 discusses how the framework proposed in the latest refresh of the New Zealand curriculum, by mirroring the cascading effect of Digital Entanglement, may promote particular body-readiness schemas which could lead to a structure that favours the emergence of a milieu of Entanglement that could redefine the student as digitally entangled person.

Each of the main sections include a Summary of Key Discussion points: Subsection 8.2.5 for Question One; and Subsection 8.3.3 for Question 2.

8.1. What is the Nature of the Entanglement between Secondary School Learners and their Digital Devices?

8.1.1. Digital Entanglement

The idea that the mind extends in loops into the world as it materially engages with it is not new (see sections 2.4 and 2.5). Discussing knapping (the art of striking rock to shape them into tools or weapons), Malafouris (2013) famously wondered if there was a way to clearly draw a line where the knapper finishes and the stone tool begins as a way to interrogate the boundaries of the mind. This idea is echoed in the work of Ingold (2000/2021), who referred to the synergy between practitioner, tool, and materials in his discussion of hand sawing. These kinds of examples of material engagement rely on the premise that humans are essentially prosthetic beings (Stiegler, 1998). Their arguments propose that we humans are the kind of beings that we are because we have used the techniques we have used (Malafouris, 2013, p. 154) and inhabited the worlds we did (Ingold, 2022a; 2022b).

In both of these perspectives, there is an entanglement with the material world we inhabit, and from which we extract (or find) the raw materials to be transformed into artefacts. By artefact I refer to a product that due to extraneous intervention and/or human agency presents itself as artificial in character. A particularity of this material Entanglement, I suggest, is that it depends on a two-pronged argument. The first argument is that organisms are embodied in particular ways. That is to say, their embodiment depends on the qualities of the world they inhabit and which they get to know through a particularly adapted suit of senses (Penny, 2021; Von Uexküll, 1934/2013). The second argument is that, because such explanations (as most of the embodied and enacted theories) are heavily anchored in a material world dominated by the laws of physics, their description of entanglement is heavily conditioned by the Causal Closure of Physics (or CCP). Simply put, CCP is a concept that says everything that happens in the physical world is caused by other physical things, and therefore the laws of physics are somehow present in all explanations (Wendt, 2015).

Discussing or describing the CCP is outside the scope of this study. However, both of these arguments converge on the argument that simulated physics (Penny, 1998) or false physic (Penny, 2023) —like those used by videogames— create a sensorimotor debility (Penny, 2022) in relation to our engagement with the world. Therefore, I introduce the CCP here only to facilitate and contextualise a discussion in relation to the digital (or explanations of digital phenomena, to be more precise). The CCP implies that, like any other sciences, social science explanations are constrained by the laws of physics (Wendt, 2015). Since physics deals with the constituent aspect of phenomena, it permeates all explanations, and as a result of this, a number of philosophers have borrowed analogies and notions from physics to describe social phenomena (Cohen, 2013).

When confronted with cognitive tasks mediated by digital devices, users construct malleable artefacts that help them transition between the device and their thinking dynamic (Rodriguez, 2025). This dynamic, I argue, although it mostly resembles the mechanisms of material engagement suggested by most enactive theorists, does so not under the governance of the laws of physics, but under the influence of digital ontophany. More precisely, the analysis of the data collected in this study seems to suggest that digital artefacts possess a set of unique properties (in that they are Explorable, Constructible, and Nomadic) whose operation cannot be explained solely from a CCP perspective (see Section 5.3). For example, in terms of Constructability, while the process of knapping can be intrinsically one of reproduction when the knapper copies a tool by shaping a particular block of flint or obsidian, neither the tool being produced nor the block of stone can be copied. Digital objects, on the other hand, can be copied, cloned, and reproduced. Moreover, Nomadicity allows for these artefacts to be not only copied, but also circulated and adapted (to practice and context).

Therefore, Digital Entanglement puts forward an *Umwelt* (in the sense of a world as it is experienced by a particular organism - Uexküll, 1934/2013) that imbues dexterity with a unique set of qualities. Digital Entanglement, therefore, can be defined as the system of engagements and hybridities between users, in this case secondary school students, and their digital devices that create potentials and entrapments. This synergy, characterised by complex hybridities and interdependencies amongst the human and nonhuman components, creates an active flow in which agency becomes a process of manoeuvrability within relational assemblages (Barad, 2007; Fenwick, 2011). The entanglement becomes an enactment in which the conditions of possibility (Kuhn, 2012; Foucault, 1971) are defined.

Ontophany is a phenomenological configuration that depends on particular cultural and historical arrangements between techniques and perception (Vial, 2013). Digital Entanglement is the projection of a new set of ontophanic properties into our capability to materially engage with digital artefacts (and, perhaps, with non-digital too). Arguably, one of the main purposes of micro phenomenology is to help us re-discover the forgotten immediacy of the experience (Bitbol, 2024). The description of the hallmarks of the experience of learning with digital devices

I undertook in Chapter 6 demonstrate this commitment. In the next sections I intend to describe, in a novel approach, how this immediacy of experience might be shaped by a new structure of perception.

8.1.1.1. Entangled Umwelt

Umwelt (Von Uexküll, 1934/2013) is a way to emphasise the situatedness and contextuality of human existence (see section 2.4). A common example of *Umwelt* is how human eyes see the world differently from that of insects and cannot perceive the reflecting ultraviolet light from flowers. Seemingly, human ears cannot perceive elephants' infrasonic calls or the ultrasonic sounds produced by bats. *Umwelt*, therefore, refers to the subjective world that an organism inhabits. A world that is shaped by the parameters of its sensory perceptions and experiences. According to Von Uexküll (1934/2013), each organism lives in its own unique environment which it perceives and interacts with, and which is distinct from the objective, external world. This self-centred, subjective universe implies that different species experience the world differently, based on their sensory and cognitive capabilities. The theory of Resonance (Raja, 2018; see section 2.6.1.5) echoes these notions and suggests that the animal (or the organism) perceives its environment by resonating to information in energy patterns. This theory highlights that ecological variables at larger scales influence neural dynamics at smaller scales, bridging the gap between environmental interactions and neural processes.

Considering that (1) the findings presented in Chapter 6 suggest that the digital can be understood as a new structure of perception with particular qualities; and (2) that these qualities differ from those described by the CCP, then these assertions seem to point towards an understanding of the digitally entangled organism as experiencing its own digital *Umwelt*. As this digitally entangled organism resonates with the energy and information patterns in this perceived world in particular ways (Von Uexküll, 1934/2013), it seems likely that this dynamic is not only restricted to the interactions between the organism and the environment, but that particular cognitive functions emerge as a consequence of these dynamic interactions (Raja, 2018). Thus, one of the possible interpretations of these assertions would be that Digital Entanglement might be understood as a particular form of cognition.

8.1.1.2. Digital Being-in-the-World: Stories of Resonance

This study has been articulated around describing the nature of the entanglement between secondary school students and their digital devices or, as I like to put it, how students and devices come and stay together. Chapter 6 addressed that question. The micro phenomenological analysis of students' MPIs suggests that the experience of students learning with digital devices presents an unfolding dynamic encompassing two overarching moments: solo drafting and assisted crafting. This process is organised in a circular sequence of eight moments where the flow of agency is distributed between the student and the device via a progressive integration of the device in the process of successfully achieving a task (see Section 7.2.2.1).

A resolution of this unfolding, integrative experience relies on a skilful transition between a landscape of affordances into a particular field of affordances (Rietveld, 2017). The activation of this readiness relies on a transition (or manoeuvrability, to use Fenwick's language) between two settings: solo and assisted; or, as suggested in Chapter 5 (see 5.1), Axiological and Praxeological. The former relates to students' considerations about the principles of learning, while the latter refers to more practical considerations (e.g.: being a good student versus accomplishing a task). This manoeuvrability does not imply a new duality (between digital and material; or solo and assisted), because it relies on a monistic interpretation of human activity. In this interpretation, (1) digital and non-digital are both expressions (mode) of the same substance; and (2) the human is de-centered in flat onto-epistemologies where human and nonhuman aspects of phenomena are mutually shaped by interpenetration.

To better understand this progressive process of integration, this study adopted Ramirez's (2018) approach to using theoretical models as tools of analysis and traced Vial's (2019) eleven dimensions on the students' stories of their digital interactions (see Section 5.3.1.1). This process revealed the scaffolding narrative that seems to support their stories. This tracing revealed a sophisticated set of emerging and progressive adaptations emerging from the dynamic coupling between learners and devices.

One of the key challenges of this study was to reconcile the emergence of the embodied paradigm with the observed practice of students using digital devices for learning. Unlike a number of other studies on embodied cognition in education that either focused on the body (Abrahamson & Sánchez-García, 2016; Gallagher, 2023; Gallagher & Lindgren, 2015; Hutto & Sánchez-García, 2015; Macrine & Fugate, 2022); or the technologies (Aguayo & Eames, 2023; Johnson-Glenberg et al., 2014; Lin et al., 2024; Lindgren et al., 2016) where particular practices were either promoted or introduced, this study intended to focus on untempered pedagogical practices as designed by the teachers and experienced by the students without any interference from the researcher (natural settings).

A second challenge of this approach to answer my research questions was that the pedagogical practices observed included a reduced variety of digital technologies (mainly laptops and tablets) and enabled limited types of embodiments (typing, clicks, and touches). Therefore, to avoid a cognitivist explanation of learning that relied on a computational depiction of the mind, it was necessary to describe the ecological dynamic. One of the reasons why identifying embodied patterns in the interviews was difficult was because that embodied interaction might be happening in the digital. However, students did not seem to have actual conscious realisation of this dynamic. My classroom observations did not show any salient pattern. To identify this dynamic, it was necessary to first open the black-box of students and devices and understand how they came and stayed together (see Section 7.2.2 for a description of the generic hallmark of the experience).

The study of the first-person recount of the experience of learning with digital devices identified three main moments: a solo drafting and an assisted crafting (preambled and closed by a moment of integration). Section 7.2 presented how the distribution of agency becomes the strategy by which the abilities of the (entangled) student and the features of the situation come together (therefore offering a contribution to the SIF framework – Rietveld, 2017). That is to say, this distribution constitutes the situation, therefore making possible the passage from a landscape of affordances into a field of affordances (see section 7.4). Students' patterns of embodiment appear to be either transparent or invisible to themselves, reflecting some form of pre-reflective action. It was only by following the circular dynamic of progressive distribution of agency that the narrow space where embodiment played a significant role in the observed interactions was revealed. Learners reported particular body-readiness in response to their digital environments. This was only possible by applying a double level of theoretical "lensing" to the findings, namely diffraction and the skill intentionally framework (i.e., the diffractive reading of Chapter 7 micro phenomenological findings via the micro ethnographic findings in Chapters 6 in regard to the emergence of a particular form of dexterity).

Raja (2018) described resonance as a dynamic in which structures inside the organism resonate to outer information in ways that can only be explained by the laws observed at an ecological scale, rather than computing outer stimuli. The present study identified digital dexterity as a form of resonance between the students and their environment (the digital) as well as a possible fractal dynamic. Extending Raja's (2018) notion of resonance to ontophanic resonance would mean that Digital Entanglement is not an instrumental relationship (Bennett, 2019; Daoud, 2020), but an emerging cognitive dynamic. Understanding the digital as a structure of perception and action (as proposed in Chapter 6) means that the constraints of the agent-environment interaction also constrain the behaviour of an intra-organismic system. That is to say, particular forms of interaction (perception) impact the emergence of cognitive dynamics, i.e., when Student 4 expressed that they were able to "zoom in" within their memories. Thompson (2017) defined cognition as the enactment of a world, "not the grasping of an independent, outside world by a separate mind or self but, instead, the bringing forth or enacting of a dependent world of relevance in and through embodied action" (p. xx). Digital Entanglement, therefore, could be understood as the emergence of a particular cognitive dynamic, since perception *of* and action *in* that world of relevance is both (1) extended and constrained by the digital; and (2) operates outside the CCP.

Digital Entanglement, thus, can be summarised as the bringing forth of a world of relevance through (digital) embodied action. Thus, merging Thompson and Raja's perspectives, it seems appropriate to suggest that Digital Entanglement's distinct modality of cognitive dynamics could be understood as a particular form of cognition. Furthermore, Digitally Entangled enaction – rather than being governed by the CCP model – might be structured around the unique set of properties of digital artefacts proposed in Chapter 5, namely, Explorability, Constructability, and Nomadicity.

Although this assertion might, initially, suggest a perpetuation of dualisms (as previously observed), I discuss in the next section how embedding Digital Entanglement in a monistic approach dissipates this initial perception.

8.1.2. Meeting the World in an Entangled Way

Micro phenomenological perspective, although a methodology in its own right, is influenced by the phenomenological background of Heidegger's (1927/1996) ideas. One of these ideas is the concept of being-in-the-world (see section 2.5.1.4). This concept explores the idea of human existence as being fundamentally intertwined with the world, that is to say, humans do not exist as isolated entities but are always immersed in a world of meaning and significance (Heidegger, 1927/1996). Being-in-the-world, therefore, refers to the idea that our very existence is characterised by our engagement with the world around us. The world becomes a matrix in which we live and move (Heidegger, 1927/1996), and we humans are inseparable from our environment. Human experience, therefore, can only be understood according to its context and situatedness.

This interconnectedness between humans and surroundings is reflected in the work of anthropologists who emphasise the continuity between the organism and the environment. In this way, being in the world becomes being of the world (Ingold, 2011), in the sense that we are not observers but active participants of this world. Human activity is shaped by our engagement and ongoing interaction with it. However, I suggest, looking at Digital Entanglement only as an act of interconnection (reticularity) or mind extension misses an important part of the argument. The findings of this study seem to point towards an integrative (entangled) dynamic, first, between students and devices (Chapter 6) and, then, between narratives and identities (Chapter 5). Digital Entanglement seems to be a cascading form of ecological resonance where the digital becomes the space where the world and the body meet.

The previous section discussed how Digital Entanglement, by favouring a particular form of resonance with the digital world inhabited and by creating a differential form of *Umwelt* and being-in-the-world, becomes a structure of perception and action. In the following subsections, I discuss how the potentials and entrapments enacted by Digital Entanglement progressively define conditions of possibility, starting with the social and extending all the way to the onto-epistemological.

8.1.2.1. Being as a Reticular Phenomenon

The findings presented in Chapters 5 and 6 of this study explored the hallmarks of the experience of learning with digital devices. Chapter 5, in particular, looks into the digital as a new structure of perception (Vial, 2019). However, it extended these ideas by identifying three constitutive triads of interaction between the dimension of the digital, which include Explorability and Constructability, articulated around reticularity, one of the dimensions of the digital identified by Vial (2019). Vial (2019) identified eleven characteristics of the digital, and Reticularity is one of them. An oversimplified way to define reticularity would be to describe it as the networked (in the sense of connected to a network), interconnected nature of the digital. This interconnection can be local (like in the case of intranets) or global (like with the internet). However, reticularity also refers to the quality of the digital to be otherfanic (Vial, 2019), since in its interconnectivity, it ‘connects’ us to others. However, in this process of connecting the I with the other, they are both brought into existence. That bringing into existence is facilitated and limited by the affordances of the platforms that enact that encounter. Reticularity, therefore, goes beyond the simple notion of networked devices as it becomes an interconnected system of potentialities (and entrapments). As Student 1 said, “[when I am connected] I'm able to get the best out of me and all the information I can have” (198). Moreover, this student statement and the critical reading of the literature seem to reveal that this reticular aspect of the digital becomes not only a new structure of perception, but also one of action. Moreover, it also becomes a structure of embodiment, in the sense that it becomes the platform where anything different to the self appears.

Reticularity has the potential to redefine both how other humans and the world at large appear. In regard to social interactions, online presence requires a form of embodied representation, commonly referred to as an avatar. These digital representations become cognitive cues that allow us to form an idea of the characteristics of our online interlocutors, a kind of declarative and performative bodily identity (Casilli, 2012; Hutchinson, 2013; Schultze, 2011, 2014). When it comes to networked environments, individuals and communities co-evolve. This self-representation chosen by individuals has an impact on the creation and evolution of its personal network. At the same time, this personal network and its changes over time influence the presence strategies and the physical and cultural characteristics displayed in profiles (Casilli, 2012; Diehl, 2020). The world at large, as presented in the previous section, also is transformed. Digital artefacts present particular properties (Explorability, Constructability, and Nomadicity) that do not necessarily reflect the CCP. Appearing (ontophany), is shaped by (1) the digital as a structure of perception; (2) the digital as a structure of action; and (3) the affordances of the reticularity. The digital, therefore, becomes an ontophanic matrix that shapes our relationships to others and the world. Moreover, it becomes the *locus* where the “I”, the world, and the other meet. This *locus* is imbued with a series of properties (Explorability, Constructability, Nomadicity) that inter-penetrate this relationality (in the same way that the rules of physics inter-penetrate the metaphors of the CCP). In this relational world, being becomes a complex and extended socio-material phenomena defined by inter-penetrations, where the boundaries are technologically extended, and both the mind and the body (as the interface to interact with the world) are saturated by the properties of the intra-action with the digital.

The advent of social media exposed the full potential of this extended idea of network, taking it beyond cyberspace and interconnection with other machines, towards a landscape of social connections, presenting the social as a phenomenon shaped by digital devices (Davidson & Joinson, 2021; Milan, 2015; Nielsen & Ganter, 2022; Ohiagu & Okorie, 2014). As explored in Chapter 2, the modalities of social bonds –like most aspects of the social– are not indifferent to changes in technological systems. They are, indeed, conditioned by them in the sense that social links within a group depend on, and are shaped by, the devices that allow them to emerge (Vial, 2019). Each technological system generates the structures according to which we construct our relationships with others, because there is always a device between ourselves and others in order to establish and maintain those relationships. These devices also include the interfaces that we use in this dialogue, and in incorporating them we also incorporate their potentialities and entrapments that reshape our social practices and our corporeality (Casilli, 2012).

This networked nature promotes new ways of living in society. Given the ubiquitousness of networks, this impact goes beyond user circles and becomes a sign of our time (Casilli, 2010; Stalder, 2018). Digital devices not only shape social practices and social connections but, as ontophanic or philosophical machines (Vial, 2019) they also have an impact on our embodiment and on how it is perceived and performed. The digital, therefore, becomes (1) the *locus* where the world and the body meet; (2) a structure of perception; and (3) a structure of action (Chapter 5); but also as the substrate of a progressive modus of engagement between students and devices, which enables the emergence of a dynamic of skilled intentionality (Rietveld, 2017) in the form of digital body-readiness (Chapter 6).

In short, **Digital Entanglement implies that being becomes a socio-material (reticular) phenomenon that enacts the "I" and others. In the process of doing so, being becomes imbued with digital properties.**

8.1.2.2. Onto-epistemology: Being-in and Being-of the World

In an onto-epistemological landscape, our understanding of existence influences our knowledge and, conversely, our methods and frameworks of knowing shape our perception of reality (see section 2.3.1.2). However, this reciprocity of knowing and being also implies an intertwining of doing (Whatman et al., 2023). Firstly, because cognition (and therefore knowledge) cannot be considered (particularly from an enactive perspective) without paying special attention to the body and its ways of being-in-the world (Varela et al, 1991/2017). And second, because in a performative understanding of being, organisms are in a constant state of becoming (Barad, 2003, 2007). Thus, an onto-epistemological understanding of students requires considering questions of being and doing as one. This re-consideration of ontology and epistemology brings forward important implications in terms of agency, since properties emerge from mutual intra-penetration, and students are extended by reticularity. Thus, digital action and digital beings are one and the same; since it is not only the mind that is extended by the use of digital devices, but also the body, since digital artefacts are essentially programable (Vial, 2019).

Digital Entanglement is a framework where this integration is seen as constitutive. It understands cognition as an enactive and ongoing process of sense-making that arises from the organism's active engagement with its surroundings. This means that knowledge is co-constructed through the organism's sensorimotor activities and the way it structures its environment. In an onto-epistemological context, like that of the present study, knowledge is inherently situated and context-dependent, shaped by the specific conditions and actions of the organism. Knowing, being, and doing are, therefore, inseparably entangled.

This entanglement is defined from the perspective of relational ontology and performativity, redefining the relations between the components of phenomena as one of inter-penetration (the mutual saturation with each other's agencies experienced by participants of phenomena). Unlike representationalist perspectives that would understand the relationship between students, devices, and objects as one in which a knower-subject reaches for a tool to study an object; a Digitally Entangled perspective prioritises the entangled aspect (the onto-epistemological relationality). That is to say, rather than an intersubjective or subject-object perspective, Digital Entanglement, as illustrated by the findings of this study, considers phenomena from an intra-relational perspective, where a progressive dynamic of distribution of agency (Chapter 6) redefined not only the conditions of possibility but also the embodied responses (Chapter 5).

To summarise, this section has shown that in a landscape of relationality relata is defined by intra-actions and not by inherit qualities, Digital Entanglement understands being, knowing, and doing as inseparable. Digital Entanglement, therefore, requires an onto-epistemological understanding of being in the world. **Digitally Entangled beings emerge from this intra-action imbued with each other's properties. Being in the world becomes being *of* the world.**

8.1.3. Extended Selves

The previous sections discussed Digital Entanglement progressively from a structure of perception to one of action and then one of being. In this section, I argue that a Cartesian understanding of technologies challenges the foundations of Digital Entanglement. Therefore, I propose a monistic approach, supported by an onto-epistemological understanding of phenomenon, to support this ecological understanding of how students and devices come and stay together.

Cartesian dualism (see Section 1.3.1.4) is one of the main challenges for the effective integration of digital technologies in the classroom, because in a context where minds and the world are separated, digital technologies are only understood as tools to act in the world. However, the findings of this research seem to indicate that, in Digital Entanglement, the digital becomes an overarching structure and not a tool. The digital is not only a structure of perception (Digital Phenomenology) but also one of action (Digital Dexterity) and therefore an essential form of being-in-the-world. Moreover, the body seems to become an extended milieu where perceptive, active, and cognitive processes take place in a reticular environment where malleability is defined by a new set of rules. That is to say, manipulating digital artefacts seems to require the digitalisation of body schemas too. This assertion both resonates and extends Stiegler's (1998) idea of bio-technical beings and Haraway's (1991) cyborgs.

Whilst onto-epistemology offers us a viable alternative to unifying knowing and being, the fundamental question of the Cartesian separation between mind and world as independent entities remains. The findings of this study seem to suggest that students and devices are entangled in complex and multilayered ways. The digital becomes a structure of perception but also one of action and, as presented in Section 5.2, an articulation point in the enaction of learners' identity. Therefore, Digital Entanglement requires the onto-epistemological argument presented in the previous sections (see 8.2.1 and 8.2.2) to be expanded by two ideas: (1) of a monistic interpretation of the mind-world duality; and (2) the encounter with that world on equal terms.

The next subsection engages with the question of monism and the inhabitation of the world. From this perspective there is no dissociation between body, mind, and world. After that I argue that, just like knapping becomes the arena where the body and the material world of objects engage, a digitally-conditioned society becomes the agora where world and body meet.

8.1.3.1. Worlds Without Dualities

Baruch Spinoza's philosophy is quite often placed in critical dialogue with the many times denounced but still persistent Cartesian dualism of Western thinking (see Section 2.3.3). Posthumanism has offered a fertile seam of literature exploring this shift from Cartesian dualism to Spinozian monism (Braidotti, 2013; Braidotti, 2016a; Braidotti, 2016b; Braidotti & Asberg, 2018; Ceder, 2020) arguably starting with Deleuze's work "Expressionism in philosophy" (1990). Spinoza's monist approach offers a holistic and immanent understanding of existence, which allows for a better understanding of Digital Entanglement. Two aspects of Spinoza's monistic perspective are of particular interest when discussing Digital Entanglement and a more integrative inclusion of digital devices both in education and education theory: First, monism sees mind and body as two attributes of the same substance, as all things in the world. For Spinoza, there is only one possible substance (that he calls God or Nature) but a multiplicity of attributes (or expressions of the substance). Therefore, when substance expresses itself through extension, we perceive the body. However, when it does it via the attribute of thought, we perceive the mind. In Spinoza's eyes, they mirror each other (Dahlbeck, 2016, p. 6).

This monistic idea is reflected in Thompson's opposition to seeing consciousness as inner experience and life as an external and mechanical structure (2007). Monism, therefore, offers a philosophical framework in which to discuss enactive principles without the risk of incongruencies. Moreover, it offers a fertile landscape for the integration of being and doing, as proposed by the present study. Moreover, Spinoza's notion of conatus, arguably, provides a concept very close to that enaction itself. *Conatus* is the innate striving for self-preservation and self-actualisation present in all things. This effort and power of life to preserve itself, I argue, links the autopoietic concern of the organism to carry on being with the Spinozian philosophy. Furthermore, Spinoza's ideas of self-preservation and the pursuit of joy or perfection support the assertion that learning is to live more and to live better (Dahlbeck, 2016) which, I suggest, can be understood as an enactive statement.

Spinoza's monism challenges both Cartesian dualism and the Humanist Anthropo-centred view, by bringing forward an integrated world without incompatible internal and external distinctions and where humans are part of a unifying vitality with the world around. This unified relationship between humans and their environments (that resounds with the ideas of flat ontologies presented before) implies not only ontological parity, but also an integrative physical inhabitation and active engagement with the world. Place and landscape have an important role in shaping human identities, practices, and ways of knowing. Anthropology (Ingold, 2006, 2011/2022, 2013, 2017, 2022b; Malafouris, 2004, 2012, 2013, 2015, 2021) and Psychology (Bateson, 1972/2000; Chemero, 2003; Gibson, 1977; Hutchins, 2008; Kellman & Garrigan, 2009; Von Uexküll, 1934/2013) support this assertion. However, one of the main contributions of the present study is to extend the idea that particular forms of dwelling promote unique forms of correspondence to the digital.

One of the main attractors in the articulation of the Two Selves metaphor that influences the dynamic either towards the Axiological or Praxiological Self was the presence of Affective, Cognitive, and/or Skill Resonance between the student and their devices, coupled with a belief in relation to the modes to obtain homeostasis (distributed agency). If the world is not a passive exterior, but rather an opportunity (an act) of coupling, this interaction (making, or doing, or acting) becomes, I argue, a process of correspondence (Ingold, 2013), as in the bringing forth of potential articulations in the world. Digital Entanglement, therefore, becomes a process of ongoing response or, I will argue, a form of resonance emerging from the students' dwelling of the digital. Moreover, it understands that social and cultural phenomena (and therefore learning) are shaped by different forms of assemblages and interpenetrations between both human and non-human —as explored in Chapter 2, the material turn of neo-materialism (Alaimo & Hekman, 2008; Barad, 2007, 2014; Bennett, 2020; Bryant, 2011; DeLanda, 2002).

Digital Entanglement thus understands the world not as a passive exterior but as an opportunity to act. In this ongoing response, participants emerge from their digital interaction *corresponding* with it. The digital becomes both the *locus* where body and world meet and engage and also the *modus* in which they drift.

8.1.3.2. Mind Extended

Although in *The extended mind* (Clark & Chalmers, 1998) there is no explicit mention of digital technologies, later works by Andy Clark, such as "Natural-born cyborgs" (2004) and its discussions of how the digital can act as a way to extend the mind, have articulated the Extended Mind Theory (EMT) into a digital narrative of sorts. Clark and Chalmers' (1998) EMT and Malafouris' Material Engagement Theory (MET) present deep connections. Both of them offer a theory of the mind organised in loops that integrate the outside world as constitutive of cognitive process and even agency. Both of these theories relate to this study in that, as presented in the previous sections of this study, the main focus of this research is to explore the links between cognitive processes and the environment, particularly in relation to the role of digital devices and this loop.

It would not be unjustified to say that the presence of digital devices in the students' cognitive process satisfies Clark and Chalmers' (1998) criteria for inclusion as part of their cognitive system. Student respondents to the Digital Survey, when asked how important was the use of their device to assist their learning (1 being very little and 5 a lot), 66% indicated either 4 or 5; which shows that devices are intrinsically embedded in student learning activities. Moreover, as suggested by the findings presented in Chapter 5 and 6, when learning with digital devices, the digital becomes both a structure of perception and a means of action (distributed agency). However, the particularities of Digital Entanglement mean that it introduces a new level of variability that further re-defines the learners' cognitive niche, creating new opportunities for plasticity.

One of the main characteristics of Digital Entanglement is that it is constituted around reticularity. Digital devices are, by definition, networked. More often than not, they are connected to the internet, and therefore to each other, and, although it can be argued that they might be used without connection, the pervasiveness of connectivity means that this is more the exception than the rule. In Aotearoa New Zealand, a 2019 report by Netsafe showed that 8 in 10 children have access to the internet when they want or need to, and that 96% of them use the internet at home, whilst 89% do so at school (Pacheco & Melhuish, 2019). According to Cullen et al. (2024), in the school setting, Aotearoa New Zealand students are amongst the world's highest users of digital devices and present the highest use of the internet in class in the world.

As explored in Chapter 5, students reported affective, cognitive and skill resonance with their digital devices, as well as a "muscle memory" (Student 6) when it comes to deploying them in class time. At the same time, the digital was described as a place where thinking happens (Student 9) or is reorganised (Student 7). Going back to Malafouris' (2013) MET, agency can be understood as distributed and relational. Moreover, as explored in Chapter 6, the learners' action readiness contingencies (Rietveld, 2014, 2017) include aspects of distributed agency amongst their own perceived abilities and those of the device as an integral part of the experience and a means to achieve homeostasis.

Bennett (2019) already pointed out that student and technology can be described as a "functionally integrated, goal-directed configuration of internal and external resources" (p. 235). However, in line with the findings (and supported by a monist understanding) it could be suggested that Digital Entanglement is not an articulation of internal and external resources, but one where all dimensions of the phenomena are component are entangled in the digital, and therefore, redefined. Being entangled is not just about being intertwined, as in the joining of separate entities. Rather, it is the lack of a self-contained existence that pre-exists interactions, it is about emerging together in an entangled intra-relating (Barad, 2007). There are no internal and external resources here, but an entangled emergence of distributed agencies that cannot be exercised independently.

This means that **Digital Entanglement understands the self as an extended one beyond the confines of the body. That extension is inextricably part of the cognitive processes**.

8.1.3.3. A Digital Condition(ing)

Therefore, and building on the arguments in the previous sections of this discussion, if we accept that Digital Entanglement is a new structure of perception, and therefore a way of acting in the world, and that all dualisms are misleading, one can argue that the digital extends the self (both mind and body).

As a result, societies are finding themselves in a new transitional space (see Sections 2.3.1, 2.3.2, and 2.4) where almost all aspects of life become dominated by computer networks. The social institutions of what the Gutenberg Galaxy (McLuhan, 2011) seem to be crumbling. Some authors explain this decline as the result of the emergence of particular forms of technologies (Vial, 2014, 2018, 2019; Volle, 1999), whilst others attribute it to new personal and collective orientations that find a vehicle through the new affordances of the digital (Fuller & Jandrić, 2019; Hayes, 2021; Kronblad & Jensen, 2023; Pepperell & Punt, 2000; Peters et al., 2018; Peters et al., 2021; Stalder, 2018). Collectively, they seem to support Digital Entanglements argument that the digital emerges as a structure of perception and action that redefines the conditions of possibilities. However, this adaptation does not seem to be so well-coordinated in the educational field (see Section 1.1). Whilst referentiality, communality, and algorithmicity (Stalder, 2018) seem to be accepted as constitutive part of our social lives, these new paradigms are seldomly addressed in educational theory, and even less in educational practice.

Digital Entanglements requires an urgency to not only include but centralise these arguments within educational discourse and practice. This is because the digital emerges as a space that overarches into the material world and embodied action. It implies an extended version of selfhood, characterised by a progressive dynamic of integration between users and devices that promotes the emergence of Entangled Body Readiness (Section 7.3). Digital Entanglement differs from tool absorption (Bell & Macuga, 2022; Lucilla Cardinali et al., 2009; Head & Holmes, 1911; Maravita & Iriki, 2004; Martel et al., 2016) in that, although body schemas are transformed to incorporate the tools at stake during tool absorption, this encounter of tool and body occurs in a shared space. However, Digital Dexterity generates a plane in which the body and the world meet in the digital space. Although I am making no claims to have evidence that analogue and digitally-mediated neural processes are different, Raja's (2018) Theory of Resonance seems to suggest that they are, and require further research.

As observed by Stalder (2018) even traditional social practices are being transformed by the entanglement with the digital, reshaping not only social contracts and participation but also the circulation and nature of cultural artefacts. These changes have profound implications on human activity but particularly for education, because they imply a new way of being in the world or, to use Wittgensteinian (1963) language, a new form of life, therefore redefining what are the affordances of a situation (Chemero, 2003, Rietveld, 2017).

As discussed in Chapter 5, digital artefacts present three main characteristics: they are Explorable, Constructible, and Nomadic. Digital artefacts are Explorable as a result of their interconnected (reticular), interactive, and ludogeneic nature. As such, they are also heavily mediated by machine sorting (algorithmic) and therefore also entangled. They are reactive and support a multiplicity of angles of action. Digital artefacts are Constructible as a result of their interconnectivity and copiability. Digital objects are instantaneously cloneable (regardless of ownership) and shareable, challenging traditional modes of circulation. Digital artefacts are Nomadic as a result of their noumenality, virtuality, and ideality. They exist in different places and no-place in particular. They can be adapted and re-programmed according to the context and the means of circulation, with disregard for genre rules. These properties of the digital (in an onto-epistemological dynamic), in turn, permeate the socio-material practices in which they are embedded, transforming the traditional ways in which cultural artefacts are created, interpreted and circulated, fostering the emergence not only a new structure of perception and action, but also particular hermeneutics.

Thus, it can be said that **Digital Entanglement understands that cultural artefacts in the digital condition have particular ways to come into existence, circulate, and make sense. Digital artefacts are Explorable, Constructible, and Nomadic, and these properties are therefore imposed on social practices.**

8.1.4. Making Sense: (Re) Constructing Niches

The previous sections discussed how in this performative understanding of the world, ontology becomes onto-epistemology, and that relationality means that properties emerge from phenomena and the interpenetration of properties. This resonance with the world we inhabit means that we are a part of it. In this context, deep learning (discussed in Section 8.2.1) becomes a form of skilled intentionality, an embodied-readiness for the world we inhabit.

In this section I discuss how in the context of Digital Entanglement, the concept of enculturation can be extended to the body, as students emerge as digitally dexterous individuals from their inhabitation of reticular worlds.

8.1.4.1. Digital Dexterity: An Enculturated Body (Self)

Digital Entanglement understands embodied practices as enculturated. The concept of enculturation is closely tied to cognitive science and anthropology (see Section 2.6.1.4). Enculturation involves learning and assimilating the beliefs, values, behaviours, language, and other cognitive tools that are characteristic of a specific culture; and it is often contrasted with acculturation, which refers to the process of acquiring the cultural traits of a different group or society. In cognitive science, enculturation has been influential in understanding how cultural context shapes cognitive processes. Hutchins (1995), for example, explored the role of enculturation in the development and use of cognitive tools. Cognitive tools are artefacts, symbols, or practices that aid in cognitive processes, such as problem-solving, memory, or communication. These tools are acquired and shaped by the cultural context in which they are used. Cognitive tools are distributed across individuals, artefacts, and the environment (Kirmayer, 2020). Enculturation involves learning how to use and interact with these distributed cognitive tools, which in turn shape and extend our cognitive abilities (Menary, 2007; Menary & Gillett, 2022). For example, writing systems, calculators, or computer software are external cognitive tools that individuals acquire through enculturation and use to augment their cognitive capacities.

The study of enculturation in cognitive science highlights the dynamic relationship between culture, cognition, and behaviour. It emphasises that cognitive processes are not isolated within individuals but are deeply embedded in the sociocultural contexts in which they occur. Therefore, by examining how enculturation shapes the acquisition and use of cognitive tools, we can gain insights into the ways culture and socio-material practices influence human thought and behaviour. **Digital Entanglement understands that participants' embodied and social practices are enculturated according to the cognitive tools used, implying that we think with the world we inhabit.**

Section 2.5 of the Literature Review presented the topics of embodiment, enactivism and materiality. Those sections illustrated the complex relationship between the body, the world and skill acquisition. In Section 7.2, I presented how from the initial stages of this research (the pilots) three moments started to appear in relation to the students experience of learning with digital devices: a solo drafting, an assisted crafting and initial and final stage of integration. It was only once I started focussing more on the assisted crafting moment that a very interesting aspect of this component started to emerge: participants were displaying (and referring to) particular forms of dexterity that did not necessarily espouse the traditional skills that would be expected for those disciplines where they were displayed.

An example of this is found when Student 9 (Art Design) referred to keyboard shortcuts as essential, whilst recognising that they were not very good at drawing. They defined the process of designing online as very physical. Moreover, Student 6 (Art Photography) and Student 9 (Art Design) described the capture of design possibilities almost as a determined by the design possibilities that were offered by the digital platform used to first record the idea and then to manipulate it. Student 5 (Art Design) decided to use a digital pad to draw, tapping into their natural ability to draw, only to realise that clicks and shortcuts were more efficient. However, one of the most striking examples was that of Student 7, who described how, when faced with a glitch in the streaming of e-sport that resulted in a single pixel on the screen appearing green, had to put themselves through a multilayer and complex process of problem-solving in order to fix it. At this point, it started to be evident to me that in order to express their dexterity in the digital, their body skills had to be digitised. Their body and their problem were meeting in a particular space: the digital.

Bernstein's idea of dexterity (1967, 1996) was not a property of the movement itself, but rather one of interaction with a changing environment. His approach was built on action in the world. What I was seeing in the student's adaptations of their problem solving-strategies was exactly that: action in the world. However, the set of dexterities needed were of a different class. They could not be explained solely with reference to the immediate world, but needed another layer: the digital. Their movements in the world were translated into particular forms of action by the affordances of the platforms and devices used. Body-schemas, it seemed, included a digital layer. Reed and Bril (1996) linked their work with that of Gibson (1974) to propose a theory of cultural ecology for human action development in which ecological niches, depending on their affordances, create a field of promoted action in which cultural influences are also influential in the acquisition of dexterity.

As presented in Section 8.2.2.1, this study intends to move away from dualities. Therefore the last thing I want to do here is to introduce a new one. Digital Entanglement, therefore, is not presented as dichotomy digital world versus "real world", rather as a possible variation of cognition in the form of embodied enculturation. In Section 2.6.1, enculturation is presented as a form of scaffolding that explains how we acquire the capacities for deploying cognitive tools when completing cognitive tasks. Section 8.2.1 points out that the findings of this study seem to suggest that Digital Entanglement might be a form of cognition and a form of (em)bodied enculturation, since the successful use of a particular cognitive tool requires not only mastery of cognitive practices but also that of the embodied manipulations of these tools (Menary & Gillett, 2022). Bringing both theoretical lines together means accepting two key points. First, dexterity is not a particular property of the movement itself but rather an effective interaction with a particular changing environment. Second, enculturated practices govern the embodied manipulations of cognitive tools and particular ways of thinking and acting in the world. Therefore, a Digital Phenomenology implies not only particular forms of action readiness (Rietveld, 2017) in the form of Digital Dexterity, but also a particular form of Digital Entanglement. In this entanglement, we not only think WITH digital artefacts but AS one, since our bodies are also enculturated, and we interact with digital artefacts exclusively through algorithmic interaction (where embodied practices must be digitised).

Digital Entanglement understands that Digital Ontophany implies the emergence of a series of progressive entanglements with the digital that culminate in a form of enculturation. Digital Dexterity is a form of this enculturation, in which the topography of action is that of the digital.

8.1.4.2. Thinking with (as) Digital Artefacts

Digital Entanglement proposes the humanist idea that "has constructed us as reasoning internalists – isolated masterful individuals in a world of objects upon which we act" (Penny, 2017, p. 276), to find our way to Ingold's (2001) idea of intelligence as a situated skill, in the sense that skills are seen "both practical knowledge and knowledgeable practice" (Ingold, 2000/2021, p. 20). However, when Penny and Ingold refer to highly located scenarios, they talk more often than not about technology and the arts, makers, artisans, and artists. They explore how the body-world system attaches and detaches from a series of assemblages as humans navigate their way through skilled living-in-the-world. In that process, each time that we use tools, we create temporary Cyborgian unions that change our relationship to the world in the same way as if we had developed a new body part (Penny, 2017). By doing so, we create a new semantic relation to the world, independently of how unimodal that extension is.

However, when we speak about digital prosthetics, the complexities demand a deeper analysis in terms of embodied cognition (Penny, 2017). In virtual reality (VR) and immersive gaming in particular, virtual prosthetics are particularly complex because just like the avatar functions as an abstract extension of the user's body; the world also becomes prosthetic. Moreover, "agency is extended into a virtual world via a virtual body, which is observed *unisensorially* (visually) but experienced in a way that conjures proprioceptive response" (Penny, 2017, p. 276). However, I argue that this is true as well outside the realm of VR and immersive gaming.

As shown in Chapter 7 (see Figure 24), one of the main points of the MP approach was to make evident the steps or moments in which the encounter between students and digital devices unfolds. The structure of the experience showed three major moments: an initial attempt and a distributed attempt, introduced and closed by a third circularly-connecting Doxa/Annexation moment. It is in this distributed attempt that that agency is distributed between the learner and the digital device and, therefore, extended (by redefining the situation and creating new affordances by the distribution). However, as presented in Chapter 6, students also referred to the screen as a "place" where certain cognitive processes occurred. Similarly, during the thematic analysis, it was noted that a progressive Digital Ontophany supported the emergence of Digital Phenomenology and Digital Dexterity. That is to say, the digital seems to have become a space where the body and the world meet (to perceive and act).

Vial (2019) distinguished between the virtual and the ontophanic in that the virtual happens exclusively in the digital world, whereas digital ontophany becomes an overarching quality that includes both the material and binary world. He argued that "we ended up literally confusing the phenomenon of the digital with the phenomenon of the virtual" (2019, p. 103). Whilst the virtual is only one of the properties of the digital, digital ontophany becomes an overarching device or matrix into which our "experience-of-the-world is cast" (Vial, 2019, p. 389). Digital Entanglement proposes to extend this idea by merging it with the notions of dwelling and correspondence, thus creating a unified language to refer to material engagement.

Dwelling refers to the ongoing, dynamic relationship between humans and their environments, which involves not only physical habitation but also active participation and engagement with the world through various sensory and cognitive processes, highlighting the significance that place and landscape have in shaping human identities, practices, and ways of knowing (Ingold, 2000/2021). Similarly, correspondence is a form of resonance between the maker and the material and a selective opening of perception to what is happening. By corresponding to the material, the maker not only responds to it, but also sets up a relation with the world (Ingold, 2013).

How does this work when the social practices we refer to belong to the digital world rather than the material one? Digital Entanglement proposes that it works the same, but differently. That is to say, it is a change of *locus* but not of *modus*. As Rietveld (2014, 2017) put it, skilled readiness and intentionality are strongly linked to the situated normativity in which a form of life is located. That attunement, which Ingold (2013) called skill, is nothing more than an embodied response to the phenomenal inter-penetration. Here is where I bring back Vygotsky and one of the initial questions of this study in relation to whether digital devices were tools or signs; whether they act outwardly towards the world (tools) or inwardly towards the subject (sign). To answer that question I will put forward a three-fold proposal. From a traditional perspective I would have said that each would belong to a different discipline: an ontological argument, an epistemological argument, and a phenomenological one. However, although still including aspects of being, knowing, and doing, I would like to bring them all together into a single onto-epistemological one.

First, this thesis has demonstrated that one of the main adversaries of effective integration of technology in education is the humanist heritage of the Anaesthetic school and its preference for dualistic oppositions: subject versus object; human versus non-human; mentalism versus material-engagement, and so on. This dualistic habit of the mind (as Barad (2007) calls it) has permeated our understanding of being-in-the-world. Neglecting Digital Entanglement, means becoming what Ingold (2013) called extra-habitants (rather than in-habitants) of the world — and learning environments. Separating individual components of phenomena is almost impossible in the long chain of (entangled) effects and agencies that constitutes it.

Second, knowing —in a monistic understanding— is profoundly redefined (as it is the knower). Learning, from a Spinozian perspective, becomes a synonym for existing more and for enhancing one’s understanding of one’s place in the world, making it an ethical enterprise (Dahlbeck, 2016) rather than a mere cognitive one.

Finally, we are nothing but what Von Uexküll (1934) called *Umwelt*. As our essential activity becomes perceiving and acting, we dwell and correspond to and with the world; not as an external environment, but in what it is to us.

So, going back to the question posed in Section 1.3.1: are digital devices a tool or a sign? Neither. And both. They are a tool to access the world, but in the process they become the world as well, the space where the mind, the body, and the world meet. Being becomes the screen (as Vial would say) and the “I” is both extended and enculturated in such a way that they become a structure of perception and, by extension, also a structure of action.

It is this inter-penetration that makes the digitally entangled self emerges imbued with digital properties. In this complex topography, agential cuts are almost impossible, as the agentic forces that shape the phenomenon engage in a turbulent and entangled flow of agency. As students become *of the* (digital) world, they become *part of* it too.

Digital Entanglement understands that we think with and as digital objects.

8.1.4.3. Postdigital Educational Influences and Theoretical Convergences

The findings of this study emerge within a broader landscape of postdigital educational theory that has fundamentally challenged traditional binary distinctions between digital and analogue approaches to learning. As argued by Jandrić et al. (2018), we are "increasingly no longer in a world where digital technology and media is separate, virtual, 'other' to a 'natural' human and social life" (p. 893). This postdigital understanding provides crucial theoretical context for interpreting Digital Entanglement as both a localised phenomenon and part of broader sociotechnical transformations.

The theoretical framework developed in this study resonates with key developments in postdigital education scholarship. Peters and Besley's (2018) established philosophical foundations that connect postdigital theory to cybernetics, complexity theory and deep learning, concepts that align with this study's integration of enactive cognition, material engagement and ontophanic resonance. Their argument that a "critical philosophy of the postdigital is dialectically interrelated with the theories such as cybernetics and complexity theory, and also processes such as quantum computing, complexity science, and deep learning" (Peters & Besley, 2018, p. 29) supports this study's interdisciplinary approach to understanding student-device entanglement.

Similarly, Knox's (2019) critical analysis of technology in education challenges instrumentalist approaches, arguing for examination of "profound and far-reaching sociotechnical relations, which have significant consequences for thinking about the purpose, focus, and governance of education" (p. 357). This critical stance informs this study's rejection of devices as tools, instead positioning Digital Entanglement as a constitutive element of students' cognitive processes. Moreover, Knox's emphasis on moving beyond "tangible devices and gadgets, towards a broader understanding of the sociotechnical systems within which the project of education is constituted" (Knox, 2019, p. 368) aligns with this study's focus on systemic entanglement rather than isolated technological adoption.

The concept of Digital Entanglement also connects to Hayes' (2021b) work on postdigital positionality, which provides a lens through educational settings might be reimagined by recognising the fluid, contextual nature of identity in digital contexts. The Tale of Two Selves identified in this study exemplifies such postdigital positionality, where students navigate between axiological and praxeological identities through their entanglement with digital devices. Hayes' insight that choices about postdigital positionality should be personal, collective and inclusive (2021b) resonates with the finding that students' resolution of tension between their Two Selves involves complex negotiations of agency and identity.

Moreover, Bayne's posthumanist approaches to digital education (Jandrić & Bayne, 2017) challenge anthropocentric assumptions underlying educational technology, arguing that mainstream educational research has not engaged substantively with digital technology partly due to education's fundamental grounding in humanist thought and continued division between an authentic inner humanness and an external and alien technology (Knox, 2019). This critique directly supports this study's posthuman, monistic approach to understanding student-device relationships as constitutive rather than instrumental.

These theoretical convergences suggest that Digital Entanglement represents not merely a localised classroom phenomenon but might be part of broader postdigital transformations in education. The findings contribute to postdigital education's commitment to examining complex entanglements between human and non-human actors whilst maintaining focus on social justice and democratic participation. As Stalder's (2018) analysis of the digital condition demonstrates, referentiality, communality, and algorithmicity have become constitutive aspects of contemporary social life, requiring educational theory to account for these new forms of meaning-making and social organisation.

Digital Entanglement understands that educational phenomena cannot be separated from broader postdigital transformations that challenge binary distinctions between human and technological agency

8.1.5. Summary of key discussion points for Q1

Digital Ontophany creates a series of progressive entanglements that culminate with the digital emerging as a place where the world and the body meet. Thus, the answer to the first research question ‘What is the nature of entanglement between secondary school students and their digital devices?’ is that Digital Entanglement:

can be summarised as the bringing forth of a world of relevance through (digital) embodied action. Thus, Digital Entanglement's distinct modality of cognitive dynamics **could be**

understood as a particular form of cognition. Furthermore, Digitally Entangled enaction might —rather than being governed by the CCP model— structure around the unique set of properties of digital artefacts proposed in Chapter 5: Explorability, Constructability, and Nomadicity.

implies that **being is a socio-material (reticular) phenomenon** that not only enacts students (mind and body) but also Others. In the process of doing so, being is imbued with digital properties.

- understands **being, knowing, and doing as inseparable.**
- advocates for an onto-epistemological understanding of being in the world. Digitally Entangled beings emerge from this intra-action imbued with each other's properties. **Being in the world becomes being of the world.**
- understands that **participants emerge from their digital interaction *corresponding***: the digital becomes the *locus* where body and world meet, engage, and drift.
- understands **the self as an extended one**. That extension is inextricably part of cognitive processes.
- understands that cultural artefacts in the digital condition have particular ways to come into existence, circulate, and make sense. **Digital artefacts are as Explorable, Constructible, and Nomadic, and these properties are imposed on social practices.**
- understands that their participants are enculturated according to the cognitive tools used. Moreover, **we think with the world we inhabit.**
- understands that Digital Ontophany **implies the emergence of a series of progressive entanglements with the digital that culminate in a form of enculturation.** Digital dexterity is a form of this enculturation in which the topography of action is that of the digital.
- Understands that student-device relationships are constitutive rather than instrumental, emerging through complex negotiations of identity within sociotechnical assemblages, and that **educational phenomena cannot be separated from broader postdigital transformations** that challenge binary distinctions between human and technological agency.
- understands that **we think with (and as) digital objects.**

8.2. What Are the Implications of This Entanglement for Learning in Secondary Schools?

The discussion of the philosophical aspects of the present study to answer the first research question “What is the nature of entanglement between secondary school students and their digital devices?” provides the theoretical foundations for the discussion of the second research question “What are the implications of this entanglement for learning in secondary schools?” To answer this question, the discussion focuses on the implications of Digital Entanglements in the classroom by using two contexts: deep learning and the latest ‘refresh’ of NCEA (National Certificate of Education Achievement). The next section looks into the connections between deep learning and being in the world, whilst Section 8.2.2 delves into how this new approach to the curriculum can lead to further Entanglement between students and their learning ecosystem.

8.2.1. Deep Learning, Technology and Lived Experience: An Enactive Reconceptualisation

Building on the theoretical foundations established in Section 2.5.5, this section examines how the findings of the present study contribute to reconceptualising deep learning within an enactive, embodied framework. The challenge lies in reconciling traditional cognitive approaches to deep learning with the embodied paradigm whilst considering the role of digital technologies in mediating learning experiences.

The traditional understanding of deep learning, whilst valuable in distinguishing approaches to learning, tends to limit interaction with the world to conceptual phenomena: "As we learn, our conceptions of phenomena change, and we see the world differently" (Biggs, 1999, p. 60). This perspective treats learning primarily as information structuring and computational processing: "The acquisition of information in itself does not bring about such a change, but the way we structure that information and think with it does" (Biggs, 1999, p. 60). Thus, education becomes conceptual change rather than the enaction of a world. However, from an enactive, being-in-the-world and being-of-the-world perspective, deep learning can only be understood as an intentional approach that connects with core motivations in an action-directed dynamic. Learning is not only perception but also action that intends to exercise change both in the way-of-life of the learners and in the world they inhabit. This requires a world-oriented effortful practice. Intentionality is not about mental representations but skilful bodily responsiveness

(Merleau-Ponty, 1962). Therefore, challenging dualisms and positioned in an enactive paradigm,.

The findings of this study support this reconceptualisation by describing how students' experiences of learning with digital devices involve progressive integration through embodied action rather than merely conceptual engagement. The identification of solo drafting and assisted crafting moments (Chapter 6) reveals a dynamic process where learners' bodily engagement with their environment becomes central to their meaning-making processes. Merleau-Ponty's (1967/2012) understanding of intentionality as skilful bodily responsiveness rather than mental representation provides a crucial bridge between deep learning theories and embodied cognition. This perspective suggests that meaningful learning involves developing what Rietveld (2017) terms skilled intentionality, an embodied readiness to respond appropriately to environmental affordances.

I would like to suggest the concept of Entangled Body Readiness (identified in Section 7.3) as an effective model of deep. This model proposes a form of deep learning that develops ecologically through learners' ongoing interactions with their digital environment. Rather than a purely mental process, this form of learning involves the development of embodied responses that emerge from the learner's situated engagement with their world. The findings suggest that Digital Entanglement creates conditions for what might be understood as embodied deep learning. Students' progressive distribution of agency between themselves and their devices (Chapter 6) represents a form of effortful practice that requires continuous adaptation and skilled responsiveness. This understanding challenges traditional distinctions between ‘course files’ and ‘life files’ (Fink & Fink, 2013) by demonstrating how digital technologies become integral to learners' lived experience rather than acting as external tools.

Digital Entanglement understands deep learning as a theory of action. That means using new knowledge in the world as effortful practice and lived experience. Action-readiness requires a series of embodied responses that emerge ecologically (in the sense that they emerge as a dynamic interaction with the environment, rather than as isolated, pre-programmed behaviour), starting in the classroom.

8.2.2. NCEA: Understand, Know, Do

In the previous section, I suggested that deep learning is not a mental process but one of action-readiness. In the next few sections, I would like to put forward an understanding of Digital

Entanglement in practice. I will do so by bringing in one of the cornerstones of the New Zealand Curriculum refresh to argue that, as students set to work, they develop an environmentally informed body readiness to the platforms with which they work. This confirms their sense of skilfulness. In turn, this sense of skilfulness affects their sense of agency by appealing to their efficacy-as-an-entangled-self, which redirects future actions in a virtuous circle. My final argument is that, as they persist on specific platforms, particular cognitive scaffolding becomes enculturated (even as embodied aspects) which further deepens the cycle.

Section 4.1.2 introduced the main ideas relating to NCEA and the curriculum refresh, particularly around the new framework, Te Mātaiaho, that integrates three elements—understand, know, do —to ensure deep and meaningful learning (Ministry of Education, 2023b). It can be argued that this framework is significant for its links to deep learning and the interconnected nature of its elements. Wood and Aitken (2023) connected this structure to schema building, arguing that learning involves more than abstract understanding, knowledge accumulation, or skill development, but also content and practice schema-building for deeper understanding. However, as I suggested in Section 5.3.1, this weaving between understand, know, and do signals a progressive integration with what Bennett and Bennett (2008) called the movement towards effortful practice and lived experience. The body is, without a doubt, our only interface with the world (Merleau-Ponty, 1962) and lived-experience cannot be referred to without a consideration for the role of that body-interface. But where is the body in this understand, know, do dynamic? In a time of analogue practices, it would have been easier to point out. It would have been in the gym, the labs, the library and the rocky shore. However, in times of simulations, VR, and remote access, the task of identifying the role of the body in these practices can be more challenging (Ingold, 2024; Penny, 2021, 2023).

A radio presenter, when discussing a report into the impact of digital technologies on health and wellbeing of children and adolescents (Cullen et al., 2024) addressed the amount of time students spent in front of screens, only to realise that he himself spent hours in front of the screen "because the world is on a screen" (Bridge, 2024, n/p.). This comment not only engages in a conversation with existing literature in relation to how digital technologies (the screen, in this example) enables the emergence of new work practices and identities (Kronblad & Jensen, 2023); but also with the findings of this research in relation to the digital as the place where the "I" and the world meet (see Section 7.2.2).

However, Te Mātaiaho also links to Section 7.1 and Section 7.2 of the present study as it proposes a cascading structure of progressive integration of skilful practice (Understand, Know, Do) that mirrors the cascading dynamic of Digital Entanglement. **Although it is not the intent of the framework, in a school context dominated by ubiquitous computing like the current one, Te Mātaiaho's description of practice as a form of onto-epistemology potentially leads the learner onto a digital niche of perceiving and acting.**

8.2.3. A Perfect Day in the Life of a Learner

Before the COVID-19 lockdowns, although remote learning and digital resources were available, they were not a priority. However, in 2020, as the world transitioned into remote learning, many schools found a particular platform as a solution for the urgent digitalisation they faced: Education Perfect. Education Perfect (EP) is an Aotearoa New Zealand company. Pre COVID, about 1,500 schools and a million students worldwide were using the platform, but that number spiked to 5,000 schools after the lockdowns (Perfect, 2024). One of the possible reasons for such a spike in adoption might have to do with the fact that EP offered a single platform solution for a number of subjects and levels, mixing tuition, real-world examples, and practice sets.

Although the effects of emergency learning during COVID has been widely studied (Aguilera-Hermida, 2020; Bond et al., 2021; Hodges et al., 2020; Hood, 2020; Müller et al., 2021; Nilsberth et al., 2021), and negative consequences were pointed out (Edge et al., 2024; Winter et al., 2021), the lasting effects of their continued use in the post-COVID classroom are not yet clear (Dunfee et al., 2024; Education Review Office, 2023; Nikolopoulou, 2023; Regnier et al., 2024). As many other secondary schools, my former school sought refuge in EP during the lockdowns. Amongst the Aotearoa New Zealand Literacy and Numeracy crisis (Hood & Hughson, 2022; van Lamoen, 2022) the Senior Leadership team wanted to look at possible links between device usage and poor performance in literacy (OECD, 2021).

One interesting finding from looking at the 2024 data from my former college relating to the use of EP, is that out of the 5 hours that students in Year 8 spend in class daily, it was not unusual for 3 of those hours to be spent on EP. Moreover, the usage of EP in the three leading faculties (Maths, English, and Science) had consistently increased (with 2024 showing a record use, even larger than during the 2022 lockdowns). The Education Review Office (ERO) confirmed that digital platforms were being used more in the classroom following the disruptions caused by COVID-19. Some academics expressed their concerns about this tendency (Gerritsen, 2023). However, I would argue that digitalisation –defined as the "sociotechnical phenomena and processes of adopting and using [digital] technologies" (Legner et al., 2017, p. 301)– has started to be recognised by scholars as one of the main influences in knowledge processes (Massa et al., 2023); research (Zaagsma, 2022); politics (Stalder, 2018); and education (OECD, 2023d; Timotheou et al., 2023), amongst others.

Imagining the possible future of education, the OECD (2020) proposed 4 likely scenarios: (1) schooling extended; (2) education outsourced; (3) schools as learning hubs; and (4) learn as you go. Each one of these possible futures embodies opportunities and challenges and could be offered off- or online. However, only a few years after proposing those scenarios, the disruptive emergence of AI propelled the publication of the report *Is education losing the race with technology?* (OECD, 2023c); where their findings seem to support a scenario where literacy and numeracy are entangled (my term) with AI, and the purpose of education becomes to teach students to work together with AI to perform these tasks.

When looking at all of these trends together, it is not surprising that some Year 8 students spend 3 out of 5 hours of the school day online. It seems to me that the role of digital devices in school would only increase, as it is increasing outside of school too. Based on this discussion it can be said that **students access increasing amounts of online content and communications for learning, and experience a significant proportion of their social and ludic life online.**

8.2.4. From Digital to Entangled

As more aspects of our daily life digitalise, so does education (Cecutti et al., 2021; Cochrane et al., 2014; Elstad, 2016; Fawns, 2022; World Economic Forum, 2015, 2017, 2023). As the number of digital platforms used in the classroom grows (Decuypere et al., 2021; Hood, 2020; Klein, 2022), so does the pace at which they are replaced (Antonini et al., 2023). This creates a fluctuating ecosystem to which learners have to constantly adapt. At the same time, the incoming framework, which presents a structure where understand, know and do components work together, is likely to lead to further entanglement due to the interwoven nature of the framework.

It is possible to argue that the introduction of Understand, Know, Do relates to the critique to the 2007 NZC and its lack of clarity around content requirements. I suggest that, although one of the main aims of Te Mātaiaho is to emphasise disciplinary knowledge (Hughson & Wood, 2022; McPhail et al., 2023), in a school context permeated by digital devices and digitalisation of resources, an unintended consequence could be the entrenchment of this particular form of inhabitation. As discussed in Section 8.2 in relation to the worlds we inhabit and in Section 2.5.1

in relation to enaction, there is a continuation between mind and life, between the organism and its environment. Moreover, according to Raja's (2018) theory (section 2.6.1.2) there is a resonance between environmental constraints and intra-organismic dynamics.

‘Understand, Know, Do’ implies a progressive integration of knowledge and practice within a disciplinary field. This integration requires a moment of inquiry (understand); one of focused learning and contextualisation (know); and one of practice (do). In this process of integration, learners will experience the tension explored in Chapter 6 (The Tale of Two Selves); which would need to be resolved one way or another. Some students would opt for the axiological self and continue with analogue integration. However, some would opt for the praxeological self, and continue an increasing pathway of integration. As explored in Chapter 7, the hallmarks of the experience of learning with digital devices is articulated around 2 main moments (the third would be the integration moment): solo drafting and assisted crafting. This dynamic calls for a progressive distribution of agency between the learner and the device to optimise the grip of the task by exploiting the selective fields of affordances, which can also be referred to as a skilled intentionality.

Therefore, one of the aspects that influence students' resolution of the tension between the two selves is their experience of efficacy at meeting the task and bringing it to a resolution. This skilled approach depends on particular schemas of body-readiness. As I suggested before, although unintentional, this might be the main contribution of Te Mātaiaho*:* the consolidation of body-readiness schemas and not, as argued by Wood and Aitken (2023), of mental schemas.

This Entangled Body Readiness (Section 7.3), which I see as the actual deep learning, or at least a precursor of it, emerges from ecological interactions between the learner and the environment. Therefore, if the first stages of Te Mātaiaho include an exploration of the landscape via the digital, chances are that the learner will identify particular fields of affordances based on the level of Entanglement experienced and the nature of the task at hand. Unless the Do is intentionally set as non-digital material practice (as in the case of STEAM approaches), the digital would not only become a structure of perception but also one of action. That is to say, the body-readiness schemas developed via the inhabitation and correspondence to the digital become enculturated cognitive and embodied practices that might direct the learner to produce further digital artefacts in a process of epicycles (see Section 2.6.1.3).

In the light of material engagement (see Section 2.6.1.2), the interaction between the organism and their environment is a recursive, dialectical phenomenon. In the classroom, these epicycles

(Thomlinson, 2017) are characterised by processes in which the students respond to their (digital) environment by producing corresponding (digital) artefacts that are fed back into the environment, which in turn impacts on the constitution and structure of the niche. This dynamic then impacts on the student again: as the organism inhabiting that niche. It can be argued that these epicycles create a milieu of Entanglement that continuously and progressively redefines the student.

As the students participating in the MPI walked into the room, some of them made direct reference to their preference for traditional or analogue learning. Some overtly mentioned that devices were not their preference. This teased my curiosity even more, because I had seen that each of them made very sophisticated uses of their devices. All of them navigated the Tale of Two Selves the best they could. They upheld for as long as they could their own axiological-self assumptions, until their praxeological-self body-readiness pulled them in another direction. That is not to say that this pull is by any means deterministic. However, it might become an inflection of their identity, and therefore a preference and a way of being in the world and, by extension, of being in the classroom.

As presented in Chapter 5, the ubiquitous presence of digital devices in the classroom introduces a particular form of ontophany: Digital Ontophany. This particular form of understanding the possibility of appearing in the world impacts on the way students engage with the world. Digital Ontophany creates progressive circles of Digital Resonance, Digital Phenomenology and Digital Dexterity that culminate in Digital Entanglement. The ontophanic resonance (skill, cognitive, and affective resonance) between students and the digital leads to the digital becoming a structure of perception (and action). I call this a phenomenological bubble: digital phenomenology. This way of being in the world and seeing all possibilities in the world (how things can appear) create particular forms of body-readiness (digital dexterity) that ultimately enculturate not only cognitive practices but embodied too, to the point that both the learners and their devices are fully entangled. I call this the Digital Entanglement. Going back to the definition introduced in Section 8.2, Digital Entanglement is the system of engagements and hybridities between secondary school students and their digital devices. These hybridities create potentials, entrapments, and interdependencies that include both the human and nonhuman components of various phenomena. And it is precisely in this entanglement where the active flow of agency runs. In it, human agency becomes no more than a process of maneuverability within relational assemblages or, as Malafouris (2013) argues, a property that is neither human nor material, but emergent from a chain of associations. This was evident, for example, in Student's 2 essay writing, for whom 500 words were too much to do on paper but attainable using a device (369). Also, on their entanglement with the device to move from what they wanted to say to how they wanted to say it (448), a process that not only required the device but depended on its capacity to 'disappear' distracting mistakes (401), correct spelling (448) and find the right word (456). Or Student 8 interactions with AI to co-construct new perspectives to historical events (212); or Student 6 reflection on how digital allowed them to add a new dimensions to their work, such as immortality (232) or extend (224) what could be done. Despite this, as pointed out in Section 2.5, there has been a "general lack of rigorous engagement with the very idea of technology in educational research" (Knox, 2019, p. 360). Furthermore, the current project of education "is overwhelmingly viewed as a matter of human development, [. . .] in which technology only features in a supporting role, typically as an uncritical 'enhancement' for learning" (Knox, 2019, p. 361).

By being part of the Entanglement, students become another flat participant of phenomena, and as such they are also imbued with the properties of the digital. In this Digital Entanglement, students not only think with digital artefacts, but they also think like one too (as discussed in Section 8.1.4.2.).

8.2.5. Summary of Key Discussion Points for Q2

The convergence of Digital Entanglement and the prevalent Understand, Know, Do in a school context dominated by digital devices has the potential to culminate in a cascading effect that privileges particular ecologies of learning. Thus, it can be argued that the answer to the second research question "What are the implications of this entanglement for learning in secondary schools?" is that:

Digital Entanglement understands deep learning as a theory of action. That means using new knowledge in the world as effortful practice and lived experience. **Action-readiness requires a series of embodied responses that emerge ecologically (starting in the classroom)**.

Although it is not the intent of the framework, **in a school context dominated by ubiquitous computing, Te Mātaiaho's description of practice** as a form of onto-epistemology, **potentially entraps the learner in a digital niche of perceiving and acting,** unless the Do is intentionally set as non-digital material practice.

Students access increasing amounts of **online content** and communications for learning and **experience a significant proportion of their social and ludic life online.**

By being part of the Entanglement, students become another flat participant of phenomena (together with other human and non-human participants), and as such they are also imbued with the properties of the digital. **In the Digital Entanglement, students not only think with digital artefacts, they think like one too**.

8.3. Summary

This chapter has discussed and answered the two research questions of the present study. The response to the first question brought together the four threads introduced in the Literature Review (Philosophy; Technology; Cognition, and Material Engagement) to establish a discussion between the findings of this research and the existing literature, and to make a contribution to the field. In the first section, I argued that an understanding of flat ontologies where the digital is ubiquitous requires a performative understanding of being, in the form of onto-epistemology. In the second section, bringing together the findings of this study and relevant theoretical frameworks, I suggested that the confluence of a monistic understanding and looping theories of the mind implied a displacement of social theories that must accommodate the digital as part of their explanation of phenomena. However, the internal dynamics of these theories still apply and confirm the uniqueness of Digital Entanglement. The first part of the Chapter closed with a discussion based on generally accepted anthropological theories of Entanglement. It suggested that Digital Entanglement becomes an overarching theory in which the "I" and the world meet in a process of correspondence where both the world and the body become digital artefacts.

The response to the second question is articulated around two main sections: a definition of deep learning and a reflection of the requirements of the New Zealand Curriculum. In the first subsection, I put forward the idea that an enactive explanation of deep learning as a theory of action must include embodiment as a central aspect, and I suggested that the findings in Chapter 7 facilitated the identification of the embodied dynamics of Digital Entanglement. Finally, the chapter ended with a discussion of how the introduction of the Te Mātaiaho framework (Understand, Know, Do), by consolidating particular schemas of body-readiness, can lead to a structure of epicycles that create a milieu of Entanglement that continuously and progressively redefines the student as digitally entangled.

Chapter 9. Conclusion

9.1. Introduction

This thesis started with the introduction of two central metaphors: the Tale of Two Schools and the Tale of Two Selves. These metaphors were linked to the emergence of this research from the identification of a gap in both practice and knowledge. Strongly positioned in the classroom, it identified a crack in relation to a discontinuity between socio-material practices inside and outside the classroom. It also argued that despite several iterations of education reform (and in spite of the contributions of the postdigital project), the core values of human-centeredness and technological periphery seem to persist. Challenging that perspective, this study presented how, far from peripheral, technology plays a constitutive role in defining what it means to be human, and how the ubiquitous presence of digital technologies has imbued our world with features that enable new ways of relating to one another and the world. Although not within the scope of this study, but this ubiquitous presence has also led to a rise in alienation, loneliness, mental health issues, cyberbullying (among other negative effects) which also need to be acknowledged. Yet, the Anaesthetic School lack of engagement with digital technologies as constitutive parts of students selves has led to a failure to recognise to what level this extension of the self impacts (both positively and negatively) educational practice.

The Tale of Two Schools, thus, becomes the Tale of Two Selves, depending on how learners resolve the tension between those paradigms. This chapter begins by recapitulating the purpose of the present research and the outcomes of each of the two research questions. These findings relate not only to the description of the hallmarks of the experience but also of the environment in which it occurs. In this environment, digital artefacts emerged as explorable, constructible, and nomadic, triggering an ecological resonance with it: entangled body readiness. Following this, I present the implications of the findings concerning teachers' conceptualisations and practice. Finally, after addressing the limitations of this research and the generalisability of the conclusions, I offer a few insights into the direction of future suggested research and closing remarks.

9.2. Overview

The purpose of the research was to investigate (1) the nature of the entanglement between secondary school students and their digital devices; and (2) the implications of this entanglement for best practice. The findings of this study demonstrated that: (1) Vial's (2019) properties of the digital were present in the students' descriptions of their interactions with digital devices; (2) that, as a result of their interactions with an environment populated by artefacts governed by Explorability, Constructability, and Nomadicity, students seem to develop particular forms of resonance and correspondence. Finally, in that ecological resonance dynamic (3) students develop forms of entangled body readiness. Whilst findings (1) and (2) answer the first research question, finding (3) can be presented as a central concept that both challenges traditional (mentalist) approaches to learning and offers a situated articulation for education best practice in the Aesthetic (postdigital) school.

Chapter 1 introduced the idea of the Tale of Two Schools as a metaphor to discuss the perceived gap in practice as the collision of different paradigms in the battleground of the classroom. Chapter 2 confirmed this perceived gap in practice as a gap in knowledge, resulting from the lack of engagement of education theory with technologies. This was linked to the primacy of mentalist or brainbound models of cognition in conceptualisations of practice in secondary school, but also to a humanistic inheritance of placing the subject at the centre and everything else (including technology) as peripheral. However, the findings of the present study demonstrated that learners and digital technologies are entangled in a dynamic coupling of progressive distribution of agency. Arriving at this conclusion implied a double consideration – from practice and theory –reflected in the selection of methodologies. Micro phenomenology was used to pursue the first-person recount of the experience, privileging the voice of students in the located context of the classroom. Micro ethnography was used to provide a social-material description not only of the environments –both social and material– where these interactions occurred but also as a way to establish a theoretical conversation with an extensive body of literature exploring the salience of material practices (Barad, 2003, 2007; Fenwick, 2015; Ingold, 2000/2021, 2011/2022, 2013; Rietveld, 2015, 2017) and material agency (Malafouris, 2013). This diffractive methodological reading made evident the architecture of both the experience (Chapter 7) and the narratives (Chapter 6) used to make sense of the topography (Chapter 5) of these environments.

9.3. Implications

The findings of this study have significant implications for both theoretical frameworks and practical applications in the field of education. By examining the nature of the entanglement between secondary school students and their digital devices, this research provides insights that challenge existing paradigms and suggest new directions for educational practice and theory.

9.3.1. Theoretical Implications

One of the key theoretical implications of this study is the reconsideration of dualism in the context of digital interactions. The findings of the present study contest dualism, the separation of mind and body, which has also permeated our understanding of technologies, by offering a monistic alternative in which the reality-virtuality continuum (Milgram & Kishino, 1994) becomes an entanglement. This shift is particularly relevant for education theories since the boundaries traditionally defining agency are blurred into an entangled flow. In considering descriptions and implications of Digital Entanglement, views that positioned the digital and real as distinct yet connected realms are challenged by the complex, intertwined nature of digital interactions described in this research. Furthermore, this study highlights onto-epistemological approaches as valid mechanisms to unify dualism, integrating being, doing, and knowing into a cohesive framework of explanation of phenomena where human and non-human elements intra-relate rather than competing for centrality. This approach aligns with postdigital and posthuman perspectives that emphasise the interconnectedness of human and technological experiences.

The findings suggest that students' experiences with digital devices are not merely extensions of their real-world interactions but are deeply integrated into their cognitive and embodied processes. This challenges educators and researchers to rethink the boundaries and intersections between digital and analogue learning environments. Furthermore, the concept of entangled body readiness introduced in this study offers a new lens through which to view learning design. This concept challenges traditional mentalist approaches that prioritise cognitive processes over embodied experiences. Instead, entangled body readiness emphasises the importance of physical and sensory engagement with digital tools, suggesting that learning is a holistic process that involves both mind and body. This theoretical shift has profound implications for how we understand and design educational experiences, advocating for a more integrated approach that values the role of the body in learning.

9.3.2. Practical Implications

The practical implications of this study are equally significant, offering concrete suggestions for improving educational practices in a postdigital age. One of the primary recommendations is creating bridges between digital and analogue experiences by tapping into the ability to interact with the world around us. Tangible User Interfaces (TUI) might be a promising approach. TUI could offer a novel approach to Digital Entanglement by integrating computing power into physical objects. This approach can simultaneously enhance students' engagement in both the digital and the world they inhabit, providing a tactile, fully-embodied experience that challenges body-mind dualities. By incorporating TUI into educational settings, educators could create interactive and immersive learning environments that foster the development of integrated dexterity.

Another practical implication is the importance of regaining lucidity by reconnecting with our experiences, as suggested by Petitmengin (2019). In an age dominated by digital interactions, it is crucial to encourage students and educators to critically reflect on their experiences of using digital devices and develop a deeper awareness and understanding of both the experience itself and how it engages with their personal learning processes. This can be achieved through practices that promote self-reflection, helping students to develop a more conscious and intentional approach to their experiences of using digital devices.

The study also raises questions about differences, similarities and complementarities between analogue and digital approaches. As more educational resources are made available only online, this transition requires careful consideration of the benefits and drawbacks. While digital tools offer convenience and efficiency, analogue methods may still hold value for certain tasks and learning processes. Educators should consider both the specific needs of their students and learning goals, particularly in relation to the development of embodied readiness, when deciding how to articulate these approaches.

The implications of this study are far-reaching, offering new perspectives on both theoretical frameworks and practical applications in education. By challenging traditional notions of dualism and emphasising the interconnectedness of the digital and the development of embodied dexterity and readiness, this research provides a foundation for developing a more integrated and holistic approach to learning. The practical recommendations, including the development of a TUI-oriented practice in the classroom; the promotion of self-reflection; and the consideration of entangled skilled approaches offer concrete strategies for enhancing educational practices in the postdigital age. As technology continues to evolve, it is essential for educators and researchers to remain adaptable and open to approaches that can support students' learning and development whilst creating a strategy for a successful encounter between students and the world.

9.4. Limitations

This study, while providing valuable insights into the entanglement between secondary school students and their digital devices, is not without its limitations. These limitations must be acknowledged to provide a balanced understanding of the research findings and to guide future studies in this area. One of the primary limitations of this study is the small number of key participants. The research was conducted with a limited sample size, which may affect the generalisability of the findings. A larger sample size would have provided a more comprehensive understanding of the phenomena under investigation and increased the robustness of the conclusions drawn. The small number of key participants also means that the study may not capture the full diversity of student experiences and interactions with digital devices. Additionally, the study was conducted in limited locations, which further restricts the generalisability of the findings. The research was confined to two specific schools and regions, which may not be representative of the broader population of secondary school students in Aotearoa New Zealand. Different schools and regions may have varying modes of access to digital devices and differing educational practices, which could influence the nature of students' interactions with technology. Expanding the study to include a wider range of locations would provide a more comprehensive understanding of the entanglement between students and their digital devices.

The study also focused on a limited range of year levels and subjects and therefore might not fully capture the variations in digital interactions across different age groups and academic disciplines. Students in different year levels and subjects may use digital devices in distinct ways, influenced by their developmental stages and the specific demands of their coursework. Future research should aim to include a broader range of year levels and subjects to provide a more nuanced understanding of how digital interactions vary across different educational contexts and educational sectors (such as ECE, primary, tertiary, community education; non-formal, informal and casual education; etc).

Another significant limitation is the reliance on participants' accounts and interpretations of their experiences. The study primarily used qualitative methods, which involved collecting and analysing participants' descriptions of their experiences. While this approach provides rich, detailed data, it is also susceptible to subjective biases. Participants' accounts may be influenced by their personal perspectives, memories, and interpretations. Triangulating these qualitative findings with quantitative data or using mixed-methods approaches could help mitigate this limitation and provide a more balanced view of the phenomena under investigation.

Another limitation that must be considered is the evolving nature of micro phenomenology, one of the main methodologies used in this research. As a relatively new and developing approach, micro phenomenology, although providing established protocols and standardised procedures, has been sparsely applied to the study of digital phenomena, which made the adaptation of the methodology challenging at times. This limitation highlights the need for further methodological development and refinement, particularly around the study of embodied practices in a digital context to enhance the standardisation of micro phenomenological research.

Furthermore, the relevance of artificial intelligence (AI) in education has significantly increased since the inception of this research. At the starting point of the study, AI was not as prominent in educational contexts as it is now. Although one of the students' experiences included AI, the accelerated progress in AI and its integration into educational practices of late have introduced new dynamics –and an extensive body of literature– that were not fully considered in this research. This limitation underscores the importance of continuously updating and adapting research frameworks to account for rapid technological advancements and their implications for education. Although the debate about the impact of technology in the classroom precedes AI, its irruption in the classroom is rapidly transforming practice. The entanglement with AI is augmenting students' capabilities at an ever-faster pace, by allowing natural-language iterative interaction to both drafting and crafting. AI becomes both a thinking and a crafting peer, which can also become invisible, giving rise to a de facto and blurry co-authoring relationship. A true offloading of the mental effort (Volle, 1999).

Finally, the study's findings must be interpreted within the context of the rapid progress in technology and its effect on education in education. The landscape of educational technology is constantly evolving, and new tools and practices are continually emerging. This dynamic environment means that the findings of this study may become outdated as new technologies and educational practices develop. Ongoing research is necessary to keep pace with these changes and to ensure that educational practices remain relevant and effective in the face of technological advancements.

9.5. Further Research

The findings of this study have opened several avenues for further research, each of which promises to deepen our understanding of the entanglement between secondary school students and their digital devices. This section outlines the key areas where additional investigation is needed, highlighting the potential for future studies to build on the insights gained from the present research.

One of the primary areas for further research is the scalability of the findings. This study was conducted with a relatively small sample size, which limits the generalisability of the results. Future research should aim to include a larger and more diverse sample to determine whether the description of the observed phenomena holds true across different populations and contexts. Investigating scalability will involve expanding the study to include a broader range of schools, regions, and educational settings. This will help ensure that the findings are robust and applicable to a wider audience, providing a more comprehensive understanding of the entanglement between students and digital devices.

Another important area for further research is the exploration of diverse types of digital devices. This study primarily focused on commonly used devices such as smartphones, tablets, and laptops. However, the digital landscape is continually evolving, with new technologies emerging that could significantly impact students' learning experiences. Future research should investigate how different types of digital devices, including emerging technologies like virtual reality (VR), augmented reality (AR), wearable devices and, in particular, TUI influence students' interactions and learning outcomes. By examining a wider range of devices, researchers can gain a more nuanced understanding of how various technologies contribute to the entanglement between students and their digital environments.

Raja's (2018) hypothesis of resonance when using digital devices presents another intriguing area for further investigation. This hypothesis of ecological cognitive architecture suggests that digital interactions can create a form of resonance where students' cognitive dynamics reflect the ecological dynamics. Testing this hypothesis would involve designing studies that specifically measure the resonance effect and the dynamic patterns at different levels (intra-organismic and ecological). Researchers should (1) test for these resonating patterns in the context of digital interactions; and (2) explore how different digital tools and interfaces facilitate or hinder said resonance, and whether certain types of digital interactions are more conducive to creating a harmonious learning experience. Understanding the mechanisms of resonance can provide valuable insights into how to design digital learning environments that optimise student engagement and performance.

The concept of digital cognition, or the idea that cognitive processes can be influenced and/or impacted by digital interactions, is another promising area for further research. This study has provided preliminary evidence that students' cognitive processes are intertwined with their use of digital devices. Future research should aim to test the hypothesis that digital cognition is a distinct phenomenon, exploring how digital tools and environments shape cognitive functions such as memory, attention, and problem-solving, as well as embodiment. Experimental studies that compare cognitive performance in digital versus non-digital contexts can help to elucidate the specific ways in which digital interactions influence cognitive practices. This type of research could inform the development of educational technologies that leverage digital cognition to enhance learning outcomes.

The hypothesis of digital dexterity, which posits that students develop specific skills and competencies through their interactions with digital devices, also warrants further investigation. This study has highlighted the importance of embodied interactions with digital tools, suggesting that students develop a form of dexterity that enhances their ability to navigate and utilise digital environments effectively. Future research should aim to measure and characterise digital dexterity, examining how it develops over time and how it relates to other forms of dexterity and skill. Longitudinal studies that track students' digital dexterity across different stages of their education can provide valuable insights into the developmental trajectory of these skills and their impact on learning.

The concept of the Two Selves – the axiological self and the praxeological self – and how they articulate – is another critical area for further research. This study has suggested that students, by resolving the tension between ontological and practical aspects of the task at hand, end up directed towards different configurations of their performative identities. Future research should explore how students articulate and integrate their axiological and praxeological selves, examining the psychological, social, and educational implications of this. Qualitative studies that enquire into students' personal narratives and experiences can provide rich insights into how they perceive and manage their identities. Understanding the articulation of the Two Selves can inform the design of educational practices that support students in navigating their worlds effectively, not as a binary disposition in which schools or students must opt for one or the other, but to engage critically with this fluidity when mapping and plotting skilled approaches development (and its assessment): teach students to write essays using digital devices would develop a set of entangled body readiness. Testing those skills on a different medium (pen and paper, with no access to online resources, etc.) might be a disservice to the learners.

There is also a need for more micro phenomenological research on the dimensions of the Digital Entanglement experience and its trans-modality. This study has utilised micro phenomenology to capture the nuanced and embodied aspects of students' interactions with digital devices. However, this methodology is still evolving, and further research is needed to refine and expand its application in the context of Digital Entanglement. Future studies should aim at exploring how different dimensions of Digital Entanglement –such as sensory, cognitive, or emotional experiences– interact and influence each other. By advancing micro phenomenological research, scholars can gain deeper insights into the complex and multifaceted nature of digital entanglement, providing a richer understanding of how students engage with digital technologies.

Finally, Chapter 5 of this study suggests that digital artefacts present a set of unique qualities in that they are explorable, constructible, and nomadic. They imbue digital artefacts with a unique form of malleability that, by extension, transforms the way we inhabit digital environments and therefore, using Malafouris' (2013) terms, how that world shapes our mind. However, these ideas need to be rigorously tested and explored to fully understand their implications and potential applications. Future research should focus on the validation and expansion of these concepts, ensuring a comprehensive understanding of how digital artefacts influence our way of relating to them (and the world) and therefore the way we think.

9.6. Final Recommendations

In closing this thesis, I would like to consider the significance of the argument(s) presented in this study; but before doing so, I will share a reflection triggered during a recent trip that might help illustrate how the notion of entanglement transcends the theoretical dimension to integrate into educational practice.

A few weeks ago, I found myself snorkelling for the first time. While trying to master this new skill, I could not help but make a link to Digital Entanglement. In my short inhabitation of that aquatic environment, I had to go through a series of ecological resonances (from the frequency and technique of my breathing, to a re-negotiated floating-based dexterity). I was truly entangled not only with the new environment but also with the artefacts that allowed me to move, breathe, see, etc. in it. Was this, I wondered, a new form of cognition? Even by staying on the surface, my body was compelled to develop new forms of dexterity. How much more would have been required if I extended my inhabitation of this environment or decided to explore its depths? I would, without a doubt, develop new embodied responses and located know-how. I would acquire new skills and body schemas whilst others would be relegated to the periphery. An educator, I thought, would not insist on me moving, breathing, or seeing in the same way I did whilst on the shore. On the contrary, they would design experiences for me to maximise this new entanglement, recognising and working with the dynamic nature of my interactions and promoting the emergence of particular embodied responses. In other words, an educator will use this resonance to design an effective learning experience oriented towards optimising the dynamic coupling between both the organism and the lived-in environment.

Similarly, the recommendations of this study aim to support educators and students in embracing and navigating the complexities of digital entanglement to enhance their overall educational experience in the postdigital age by integrating ecological resonances into practice. The findings of this research underscore the profound impact of digital devices on secondary school students' learning experiences and highlight the need for a nuanced approach to integrating technology in educational settings. Based on the insights gained from this study, several key recommendations can be made to enhance educational practices and support students in navigating the complexities of Digital Entanglement. Firstly, it is essential to recognise the dynamic nature of students' interactions with digital devices. Educators should strive to create learning environments that leverage the properties of digital artefacts – Explorability, Constructability, and Nomadicity –to foster deeper engagement and active participation by supporting the learners' resonance with their environment (affective, cognitive, and skills). Also, acknowledging this cascading resonance and the progressive distribution of agency, educators should design curricula and instructional strategies that incorporate these dynamics, facilitating a more immersive and resonant learning experience that aligns with students' natural interactions with technology. Moreover, the concept of entangled body readiness, which emerged as a central finding of this study, should be integrated into educational practice. This concept challenges traditional mentalist approaches of learning by emphasising the salience of physical and sensory engagement with digital tools.

Finally, this study highlights the need to bridge the gap between digital and analogue experiences. While the use of digital devices offers numerous benefits, it is crucial to balance these interactions by providing a well-rounded educational experience in which the learner has the opportunity to develop fine motor skills as well as digital dexterity. Tangible User Interfaces (TUI) might present a promising approach to achieving this balance by integrating physical objects with computing interactions and therefore closing the gap between embodiment and computing capabilities as well as tapping on existing embodied readiness. Educators should explore the use of TUIs to create interactive and engaging learning environments that foster embodied responses, movement and object manipulation. Furthermore, the rapid advancement of artificial intelligence (AI) and its increasing relevance in education necessitates continuous adaptation and updating of research frameworks. The recommendations derived from this research emphasise the need for an integrated approach to technology in education practice, as well as the recognition of the level of integration between the use of digital devices and cognitive processes.

This thesis opened by reflecting on iterations of education reform and the changing landscape of the classroom. In this context, educators face extended, augmented students whose boundaries are both blurred and infinite due to the reticular/interconnected nature of the digital phenomenon. I would like to conclude by hoping that the findings of this study help design learning episodes that, by integrating socio-material practices and agencies, embrace the entangled students and their way of sensing and acting in the world. Doing so will facilitate the passage from an anachronic Anaesthetic school into a postdigital Aesthetic and contribute to the ever-evolving project of re-writing the grammar of schooling (Tyack & Tobin, 1994).

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Appendices

Appendix A: Ethics Approval

Auckland University of Technology Ethics Committee (AUTEC)

Auckland University of Technology
D-88, Private Bag 92006, Auckland 1142, NZ
T: +64 9 921 9999 ext. 8316
E: ethics@aut.ac.nz
www.aut.ac.nz/researchethics

26 July 2022

Claudio Aguayo
Faculty of Centre for Teaching and Learning

Dear Claudio

Re Ethics Application: **22/114 Digital entanglement: a study on how students and devices come (and stay) together**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 26 July 2025.

Non-Standard Conditions of Approval

1. Amendment of all information sheets (Principle, Teacher and Student) advising of where and when interviews are taking place.

Non-standard conditions must be completed before commencing your study. Non-standard conditions do not need to be submitted to or reviewed by AUTEC before commencing your study.

Standard Conditions of Approval

1. The research is to be undertaken in accordance with the Auckland University of Technology Code of Conduct for Research and as approved by AUTEC in this application.
2. A progress report is due annually on the anniversary of the approval date, using the EA2 form.
3. A final report is due at the expiration of the approval period, or, upon completion of project, using the EA3 form.
4. Any amendments to the project must be approved by AUTEC prior to being implemented. Amendments can be requested using the EA2 form.
5. Any serious or unexpected adverse events must be reported to AUTEC Secretariat as a matter of priority.
6. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the AUTEC Secretariat as a matter of priority.
7. It is your responsibility to ensure that the spelling and grammar of documents being provided to participants or external organisations is of a high standard and that all the dates on the documents are updated.
8. AUTEC grants ethical approval only. You are responsible for obtaining management approval for access for your research from any institution or organisation at which your research is being conducted and you need to meet all ethical, legal, public health, and locality obligations or requirements for the jurisdictions in which the research is being undertaken.

Please quote the application number and title on all future correspondence related to this project.

For any enquiries please contact ethics@aut.ac.nz. The forms mentioned above are available online through http://www.aut.ac.nz/research/researchethics

(This is a computer-generated letter for which no signature is required)

The AUTEC Secretariat
Auckland University of Technology Ethics Committee

Cc: cristianrodriguezmz@gmail.com; Stanley Frielick

Appendix B: Tools

a. MPI Sample Interview Questions

TE WĀNANGA ARONUI O TĀMAKI MAKAU RAU

Micro Phenomenological Interview - Sample Questions

Project title: Digital entanglement: a study on how students and devices come (and stay) together.

Project Supervisor: Dr Claudio Aguayo

Researcher: Cristian Rodriguez

Note:

The Micro-phenomenological Interview (MPI) is a guided instrospective tool designed to explore a singular experience. Although the method follows a rigourous structure (see the sections below), it is impossible to pre-determine a set of questions, other than the opening statement.

The method is designed to guide the participant through the evocation of a particular experience in order to unfold its structure; first at a diachronic level (the different "moments") and then exploring the micro-actions of those "moments" (the synchronic level).

The interviewer starts with a formulaic statement, designed to confirm consent and to connect the interviewee with a singular experience. After that, a number of techniques (exploration of the perceptual; resonance; recapitulation; fragmentation; questioning of action and processes; etc.) are used to guide the interviewee's exploration of their own experience. Particular questions will depend on the nature of the content and structure of the experience explored. An example of an MPI interview is provided below.

The sections below offer a glance into the MPI.

Structure of the interview:

The purpose of a Micro Phenomenological Interview (MPI) is to obtain a detailed description of a singular experience, focussing on the 'how' rather than the 'what' (Petitmengin, 2006; Petitmengin et al., 2013; Petitmengin et al., 2018; Vermersch, 1991).

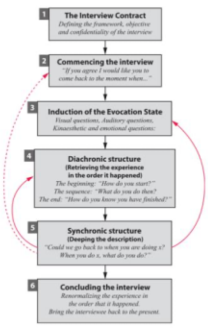

Fig 1- **Example of a typical MPI structure (Hogan et al., 2016, p. 2582)**

Starting of a MPI

All MPIs start with this formulaic introduction, design to renew consent and to identify the singular experience.

> ***I would like to invite you, if you agree, that you take the time you need to connect with the moment that you** [singular experience]**. Once you have done that, please let me know.***

After that the interviewer would focus on helping the interviewee to evoke the singular experience, but mainly asking questions related to sensory motor recollections.

Where were you at the time?
Where you sitting or standing?
Who was around you?
Where was your device placed

Identifying the diachronic and synchronic axes

Once the interviewee is connected with the singular experience (evoking), the interviewer moves to identify the 'moments' of the experience, by following the actions.

What did you do then/first/to start the task?
How did you access that information?
What did you do with your device?

After the "moments" are identified, the interviewer will help the interviewee to unfold those moments.

If you agree, let's go back to the first moment when you opened your device. How did you know you needed to use your device then?
…and when you were completing that form, were you recalling information from the text or were you looking at it on your device?

Concluding a MPI

Once the synchronic and diachronic structure of the experience have been explored, the interviewer corroborates his recollection of the singular experience with the interviewee by reconstructing the timeline and main actions mentioned during the interview.

If I understand correctly, you first…. then you…. and you finished by… Is that correct?

After corroborating the that the information captured by the interviewer reflects the singular experience as lived by the interviewee, a chance to add any more information is given

Is there anything else you want to add? Something I have no asked or that you would like to mention?

Example of a MPI

"Can we go back to that moment when you read the data visualization..., so when was this?"
"Ah... quarter past 7 this morning."
"Ok and where are you?"
"At work."
"At work ok, so are you at a desk?"
"I was at my desk, yeah."
"Ok, and when you are at your desk, are you sitting or standing?"
"Sitting..."
"Are you sitting upright?"
"Yeah..."
"So are you very straight, is your back very straight or...?"
"It could be that I am leaning forward on the desk or I am sitting up right. [bends forward and back in the chair]"
"And are your hands on the table or are they on your body?"
"No, I kind of think that I have the feeling that I am leaning forward, more leaning onto my hands."
"So you are leaning on your hands?"
"Yeah, underneath my chin. [mimics the pose she was in]"
"Ok, and you have the computer screen in front of you... Is there anything else on the desk besides the computer screen?"
"[long pause] Yeah, I have my keyboard, I have my drink bottle, I have my coffee."
"Where is your coffee, on the left, or...?"
"On the left..."
"And is it strong coffee?"
"Yes, strong and freshly made."

"Can you smell it, now?"
"Yes very much so..."

Source: Hogan et al., 2016, p. 2583

Approved by the Auckland University of Technology Ethics Committee on *type the date final ethics approval was granted*, AUTEC Reference number *type the reference number*.

References

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3.

4.

5.

b. Generalised Observation and Reflection Platform (GORP) & Observation Protocol

Observation Protocol

Project title: Digital entanglement: a study on how students and devices come (and stay) together.

Project Supervisor: Dr Claudio Aguayo

Researcher: Cristian Rodriguez

Tool 1: GORP

The Generalized Observation and Reflection Platform (GORP) is a tool develop by the Centre for Educational Effectiveness of the University of California, Davis campus. in 2014 by the University of California, Boulder campus added an observation protocol called Observation Protocol for Learning Environments. The protocol allow observer to quantify educational practices in classroom environments.

The original protocol enables the observer to click a series of buttons on the platform, which in turn create a time stamp of the strategies used during the lesson.

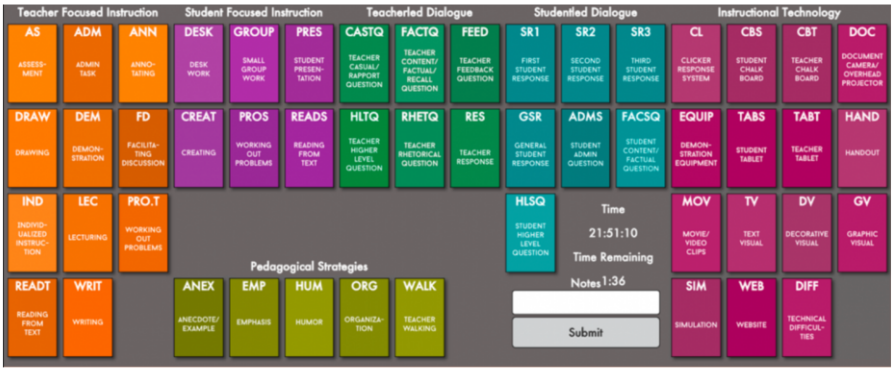


Fig. 1: Observation Protocol for Learning Environments

The protocol in use for this research is an adaptation of the original one (Fig. 2).

Fig. 2: Observation Protocol Digital Entanglement

Tool 2: Video-recording

The first point of data collection is a class visit where the participant will be learning with digital devices. The lesson will be recorded from different angles (2 video recorders). This will be done in conjunction with the researchers record of the observation using GORP.

Only participants who have signed the consent and release form will be recorded.

Fig. 3 shows the classroom arrangement for video-recording.

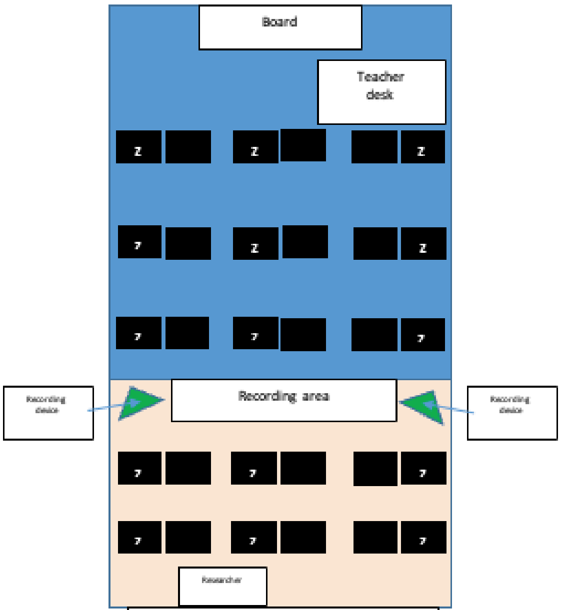


Fig. 3 Video-Recording classroom configuration

Desirable images/activities:

- Learners' interactions with their devices.
- Learners' negotiations about assemblages.
- Technological assemblages.
- Cognitive assemblages (digital or non-digital).
- Image labels with date and time.

Approved by the Auckland University of Technology Ethics Committee on *26 July 2022*, AUTEC Reference number *22/114*.

c. Post observation digital survey (Google Form)

TE WĀNANGA ARONUI O TĀMAKI MAKAU RAU

Initial Interview Questions

The questionnaire will be distributed via Google Classroom after the video-recorded session and the answers discussed during a 15-minute interview.

1- Please indicate how much you used your device to assist your learning during [the recorded session].

1-Not much

5-A lot

2- Please indicate how important was the use of your device to assist your learning during [the recorded session]

1-Not very important

5-Very important

3- Please indicate in what ways (if any) interacting with your device assisted your learning.

4- Please briefly describe the digital device(s) you were using during [the recorded session].

5- Would you be willing to have a 15minute follow up interview to discuss your learning experience?

1-Yes

2-No

Thank you for your time.

Approved by the Auckland University of Technology Ethics Committee on *26 July 2022*, AUTEC Reference number *22/114*.

d. Letter requesting access

My PhD research this year - Request for Permission to access the College

Princip...2023).docx | Permiss...dents.pdf

Diego Cristian Rodriguez

To: [redacted]

Reply | Reply all | Forward

Sat 21/01/2023 4:39 PM

Principal Information-Sheet- ... 71 KB

Permission for researchers to... 148 KB

2 attachments (219 KB) Save all to OneDrive - AUT University Download all

Hi Steve

Happy New Year. I hope this email finds you well.

Although 2022 was a complicated year, some very good things happened too. Firstly, through some academic connections, I got in touch and was accepted to be part of Embodied Underground (an arm of the Embodied Design Research Laboratory at UC Berkeley, led by Dr. Dor Abrahamson, one of the leading voices on contemporary research and design on embodied cognition). Also, I am very happy that I was lucky enough to have been chosen as the recipient of one of the doctoral prime Minister Scholarships for 2023. So as a result, I will be completing a 3-month internship at the University of La Serena in Chile, the cradle of the cognitive School of Santiago that I follow. So a lot of things happening this year again!

In the meantime, we are about to head back into the 2023 academic year and, as we discuss last year, my hopes are to be able to complete my research on the role of digital devices in the classroom this year. I hope it is still OK with you for me to come to [redacted] complete it.

I am attaching an information sheet with some details about my project and a *Permission for access to the organisation* form for you to sign.

My intention would be to come to [redacted] during term 1, probably before the T1 Assessment, for a quick chat with the classes to take part (I don't need more than 3 classes). I would, then, come back in the second half of the term to conduct the recordings and interviews. I would only work with Y12 and Y13 students. This is qualitative rather than quantitative research, and I would end up working with a reduced number of students (a maximum of 10 key candidates).

I am happy to answer any questions you might have either in writing or in person.

Kind Regards
Cristian

Permission for researchers to access organisation school staff / students.

Project title: ***Digital entanglement: a study on how students and devices come (and stay) together***

Project Supervisor: ***Claudio Aguayo***

Researcher: ***Cristian Rodriguez***

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 15th April 2022.
- ○ I give permission for the researcher to undertake research within ________________________________
- ○ I give permission for the researcher to access the staff / students / employees of ______________________

Principal's signature: ....

Principal's name: ....

Principal's Contact Details (if appropriate):

....

....

....

....

Date:

Approved by the Auckland University of Technology Ethics Committee on *26 July 2022*, AUTEC Reference number *22/114*.

Note: The head of the organisation should retain a copy of this form.

Principal Information Sheet

Date Information Sheet Produced:

15th April 2022

Project Title

Digital entanglement: a study on how students and devices come (and stay) together.

An Invitation

My name is Cristian Rodriguez. I used to be a Head of Faculty and Director of Digital Learning at [redacted] College and I am currently an Assistant Principal at [redacted] College. I am a PhD candidate at Auckland University of Technology. I am interested in how learners and digital devices come together to facilitate learning. As part of this degree, I am undertaking a research project leading to a thesis. I am inviting secondary school learners to participate in this study.

If you agree to grant me access to [redacted] College for the purpose of this study (I am also attaching the *Permission for researchers to access organisation school staff/students* form), I would be sending invitations to teachers and subsequently to learners to take part in this research. Participation is voluntary. The recording and interviews will take place during Term 1 2023 within the [redacted] College campus.

The study is organised in three stages: The videorecording of a lesson in which students use digital devices to learn; a short semi-structured interview; and possibly a 60-minute interview to explore their own experience of learning with digital devices.

Participants will first be recorded as part of a class participating in a learning task involving digital devices. After that, the semi-structured interview will take approximately 15 minutes and will aim at exploring how students used their devices during the recorded lesson (Was it essential for their learning? What did they do with it?; etc.). The second interview, a few days after, will look at the same experience in the same lesson, but in more detail. It will take around 60 minutes and it will try to identify the sequence of actions of their use of the device and the structure of those actions, with the goal of comparing different experiences and trying to identify common elements. The interviews will take place in the Admin Meeting Room during one of the students' study periods.

Should they feel the need to withdraw from the project, they may do so without question at any time before the data is analysed. They just need to let me know at any time, before, during or after any of the stages.

Responses collected will form the basis of my research project and will be put into a written report on an anonymous basis. It will not be possible for them to be identified personally. All material collected will be kept confidential. No other person besides me and my supervisor, Dr Claudio Aguayo, will see the interviews or video-recordings.

The thesis will be submitted for marking to the Faculty of Māori and Indigenous Development and deposited in the University Library. It is intended that one or more articles will be submitted for publication in scholarly journals. All recordings will be destroyed after the end of the project.

If you have any questions or would like to receive further information about the project, please contact me at bkw4037@autuni.ac.nz or my supervisor, Dr Claudio Aguayo, at *Te Ara Poutama*, Faculty of Māori and Indigenous Development, 55 Wellesley Street East, Auckland 1010, phone 921 9999 extension 5253 or at Claudio.Aguayo@aut.ac.nz

What is the purpose of this research?

This research aims at investigating how learners and digital devices come together to collaborate in learning processes. I am particularly interested in the learners' voice in describing this process. My objective is to investigate how learners experience digital learning and if there is any common structure across different experiences.

The findings of this research may be used for academic publications and presentations.

How was [redacted] College identified and why am I being invited to participate in this research?

I am particularly interested in how students and devices interact in order to facilitate learning, particularly when it comes to deep learning. During my time at [redacted] I was witness to a number of strategies and articulations that the students were putting in place in order to maximise their learning, and it is in these particular groups that I am interested.

How do students agree to participate in this research?

If a student wishes to participate in this research, I will send them a consent form to complete. They can always contact me if they have any questions.

Students' participation in this research is voluntary, and whether or not they choose to participate will neither advantage nor disadvantage them. They are able to withdraw from the study at any time. If they choose to withdraw from the study, then they will be offered the choice between having any data that is identifiable as belonging to them removed or allowing it to continue to be used. However, once the findings have been produced, removal of their data may not be possible.

What will happen in this research?

The first step of the research is the videorecording of some lessons. The recording is not particularly focused on the students. It is a record of the interaction between them and their digital devices (What are the devices used for? How often? At what stage of the learning and with what purpose? Do all students use their devices at the same time and for the same purpose, etc). It would inform some of the questions I might ask them during the interviews. The first interview helps me identify scenarios of particular interest (where learning and the use of digital devices are particularly linked). This interview is about 15 minutes long and will ask the learners for general details of their actions during the recorded lessons.

Those students whose use of digital devices prove particularly interesting, would be invited for a second interview. This is a longer and more in-depth interview. It takes about 60 minutes, and it focuses on evoking the experience of learning with devices in order to identify "moments" and the description of those "moments". This longer interview will take place in the Admin Meeting Room within school hours (during one of their Study Periods). I would use that material to analyse and compare the answers in search for common elements.

What are the discomforts and risks?

I am not foreseeing any discomforts. The interview intends to bring light to students' experience of learning with devices. As a result of the interview, learners might come to realise aspects of that experience that seem unexpected to them. If they don't feel comfortable at any time, they might stop the interview or participation altogether.

What are the benefits?

This research intends to understand the dynamics of interactions between learners and digital devices from the perspective of the learners. It will aim at describing the structure of that experience and look for common elements across learners' experiences.

It would allow learners to better understand the ways in which they use their devices to support their learning. In turn, this understanding will help you as an educator to design better learning experiences including digital devices.

At a personal level, this research will assist me in obtaining my PhD qualification.

What compensation is available for injury or negligence?

This is a low-risk study. It is unlikely that any physical injury will result from your participation in this study.

How will my privacy be protected?

I will keep all the research information shared with me confidential. I will not discuss or share the research information with anyone other than with my Supervisors or the thesis Examiners

Research data will be retained only without any identifiers so that individual participation is anonymous. Video-recordings will be kept without any identifiers, but images cannot be anonymised. However, no video-recordings will be ever published.

All information from participants will be secured under password protected platforms and these will be destroyed after 6 years.

What are the costs of participating in this research?

There will be no cost to you other than the time spent on the completion of the consent forms and interviews.

What opportunity do I have to consider this invitation?

A month.

Will I receive feedback on the results of this research?

Should you decide to participate, a URL at which you will be able to read a summary of the findings will be made available to you once the research analysis is finished. A copy of those findings will also be made available to the Principal and the School.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, ***Dr Claudio Aguayo***, *Claudio.Aguayo@aut.ac.nz* ***+64 921 9999 ext. 5253***

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, *ethics@aut.ac.nz* , (+64) 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Cristian Rodriguez

Bkw4037@autuni.ac.nz

Project Supervisor Contact Details:

Dr Claudio Aguayo,

Claudio.Aguayo@aut.ac.nz

+64 921 9999 ext. 5253

Kind Regards

Cristian Rodriguez

e. Participant Information Sheet

Participant Information Sheet

Date Information Sheet Produced:

15th April 2022

Project Title

Digital entanglement: a study on how students and devices come (and stay) together.

An Invitation

My name is Cristian Rodriguez. I used to be a Head of Faculty and Director of Digital Learning at Macleans College and I am currently an Assistant Principal at Whangaparaoa College. I am a PhD candidate at the Auckland University of Technology, and I am interested in how learners and digital devices come together to facilitate learning. As part of this degree, I am undertaking a research project leading to a thesis. I am inviting secondary school learners to participate in this study.

The study is organised in three stages: The videorecording of a lesson in which students use digital devices to learn; a short semi-structured interview; and possibly a 60-minute interview to explore your own experience of learning with digital devices. The recording and subsequent interviews will take place during Term 1 2023.

The semi-structured interview will take approximately 15 minutes and it will aim at exploring how you used your device during the recorded lesson (e.g. Was it essential for your learning? What did you do with it?; etc.). The second interview will look at the same experience, but in more detail. It will take around 60 minutes. It will try to identify the sequence of actions of your use of the device, and the structure of those actions; with the goal of comparing different experiences and try to identify common elements.

Should you feel the need to withdraw from the project, you may do so without question at any time before the data is analysed. You just need let me know at any time, before, during or after any of the stages.

Responses collected will form the basis of my research project and will be put into a written report on an anonymous basis. **It will not be possible for you to be identified personally**. All material collected will be kept confidential. No other person besides me and my supervisor, Dr Claudio Aguayo, will see the interviews and video recordings.

The thesis will be submitted for marking to the Faculty of Māori and Indigenous Development and deposited in the University Library. It is intended that one or more articles will be submitted for publication in scholarly journals. All recordings will be destroyed after the end of the project.

If you have any questions or would like to receive further information about the project, please contact me at bkw4037@autuni.ac.nz or my supervisor, Dr Claudio Aguayo, at *Te Ara Poutama*, Faculty of Māori and Indigenous Development, 55 Wellesley Street East, Auckland 1010, phone 921 9999 extension 5253 or at Claudio.Aguayo@aut.ac.nz

What is the purpose of this research?

This research aims at investigating how learners and digital devices come together to collaborate in learning processes. I am particularly interested in the learners' perspective on describing this process. My objective is to investigate how learners experience digital learning and if there is any common structure across different experiences.

The findings of this research may be used for academic publications and presentations.

How was I identified and why am I being invited to participate in this research?

I selected three classes to represent different instances of learning with digital devices (content-heavy learning, self-organising learning, and action-based learning). You are now invited to express your interest on participating in the next stages of the research: a video recording of that lesson, a Google Survey followed by a 15-minute interview about it, and possibly an extended 60-minute interview if you are selected.

How do I agree to participate in this research?

If you wish to participate in this research, please contact me, I will send you a consent form to complete. After this, I will come to your class to video-record a pre-arranged lesson. We will then arrange a time to meet during your school day to complete the first 15-minute interview and (possibly) the final 60 minute one.

Your participation in this research is voluntary (it is your choice) and whether or not you choose to participate will neither advantage nor disadvantage you. You are able to withdraw from the study at any time. If you choose to withdraw from the study, then you will be offered the choice between having any data that is identifiable as belonging to you removed or allowing it to continue to be used. However, once the findings have been produced, removal of your data may not be possible.

What will happen in this research?

The first step of the research is the videorecording of one of your lessons. The recording is not particularly focused on you. It is a record of the interaction between students and digital devices (What are the devices used for? How often? At what stage of the learning and with what purpose? Do all students use their devices at the same time and for the same purpose? etc.). It would inform some of the questions I might ask during the interviews. The first interview helps me identify scenarios of particular interest (where learning and the use of digital devices are particularly linked). This interview is about 15 minutes long following a short Google Form Survey and will ask you for general details of your actions during the recorded lessons.

Those students whose use of digital devices prove particularly interesting, would be invited for a second interview. This is a longer and more in-depth interview. It takes about 60 minutes, and it focuses on evoking the experience of learning with devices in order to identify "moments" and the description of those "moments". This longer interview will take place in the Admin Meeting Room, within school hours (during one of your Study Periods). I would use that material to analyse and compare the answers in search for common elements.

What are the discomforts and risks?

I am not foreseeing any discomforts. The interview intends to bring light to your experience of learning with devices. As a result of the interview, you might come to realise aspects of that experience that seem unexpected to you. If you don't feel comfortable at any time, you might stop the interview or your participation altogether.

What are the benefits?

This research intends to understand the dynamics of interactions between learners and digital devices from the perspective of the learners. It will aim at describing the structure of that experience and look for common elements across learners' experiences.

It would allow you to better understand the ways in which you use your device to support your learning. In turn, this understanding will help educators design better learning experiences including digital devices.

At a personal level, this research will assist me in obtaining my PhD qualification.

What compensation is available for injury or negligence?

This study is a low-risk study. It is unlikely that any physical injury will result of your participation in this study.

How will my privacy be protected?

I will keep all the research information shared with me confidential. I will not discuss or share the research information with anyone other than with the Supervisors or the thesis examiners.

Research data will be retained only without any identifiers so that individual participation is anonymous. Video-recordings will be kept without any identifiers, but images cannot be anonymised. However, no video-recordings will be published.

if you withdraw from the study, you will be offered the choice between having any data that is identifiable as belonging to you to be removed or allowing it to continue to be used. However, once the findings have been produced, removal of your data may not be possible.

All information from participants will be secured under password protected platforms and these will be destroyed after 6 years.

What are the costs of participating in this research?

There will be no cost to you other that the time spent on the completion of the consent forms and interviews.

What opportunity do I have to consider this invitation?

A month.

Will I receive feedback on the results of this research?

Should you decide to participate, a URL at which you will be able to read a summary of the findings will be made available to you once the research analysis is finished. A copy of those finding will also be made available to the Principal and the School.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, ***Dr Claudio Aguayo,*** *Claudio.Aguayo@aut.ac.nz* ***+64 921 9999 ext. 5253***

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, *ethics@aut.ac.nz* , (+64) 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Cristian Rodriguez

Bkw4037@autuni.ac.nz

Project Supervisor Contact Details:

Dr Claudio Aguayo,

Claudio.Aguayo@aut.ac.nz

+64 921 9999 ext. 5253

Kind regards

Cristian Rodriguez

f. Consent forms

AUT
TE WĀNANGA ARONUI
O TĀMAKI MAKAU RAU

Teacher Consent Form

Project title: ***Digital entanglement: a study on how students and devices come (and stay) together.***

Project Supervisor: ***Claudio Aguayo***

Researcher: ***Cristian Rodriguez***

- O I have read and understood the information provided about this research project in the Information Sheet dated 15th April 2022.
- O I have had an opportunity to ask questions and to have them answered.
- O I understand that no changes to my planning or teaching will be needed other that including devices.
- O I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without being disadvantaged in any way.
- O I understand that if I withdraw from the study then I will be offered the choice between having any data that is identifiable as belonging to me removed or allowing it to continue to be used. However, once the findings have been produced, removal of my data may not be possible.
- O I agree to take part in this research.
- O I allow access to my classroom (please tick one): YesO NoO
- O I allow the recording of my .... class (please tick one): YesO NoO
- O I wish to receive a summary of the research findings (please tick one): YesO NoO

Participant's signature: ....

Participant's name: ....

Participant's Contact Details (if appropriate):

....

....

....

....

Date:

Approved by the Auckland University of Technology Ethics Committee on *26 July 2022*, AUTEC Reference number *22/114*.

Note: The Participant should retain a copy of this form

Participant Consent Form

Project title: ***Digital entanglement: a study on how students and devices come (and stay) together.***

Project Supervisor: ***Claudio Aguayo***

Researcher: ***Cristian Rodriguez***

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 15th April 2022.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that notes will be taken during the interviews and that they will also be audio-taped and transcribed.
- ○ I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without being disadvantaged in any way.
- ○ I understand that if I withdraw from the study then I will be offered the choice between having any data that is identifiable as belonging to me removed or allowing it to continue to be used. However, once the findings have been produced, removal of my data may not be possible.
- ○ I agree to take part in this research.
- ○ I wish to receive a summary of the research findings (please tick one): Yes○ No○

Participant's signature: ....

Participant's name: ....

Participant's Contact Details (if appropriate):

....

....

....

....

Date:

Approved by the Auckland University of Technology Ethics Committee on *26 July 2022*, AUTEC Reference number *22/114*.

Note: The Participant should retain a copy of this form

TE WĀNANGA ARONUI O TĀMAKI MAKAU RAU

Consent and Release Form

Project title: ***Digital entanglement: A study of learning with digital devices in a NZ secondary school***

Project Supervisor: ***Claudio Aguayo***

Researcher: ***Cristian Rodriguez***

- O I have read and understood the information provided about this research project in the Information Sheet dated 15th April 2022
- O I have had an opportunity to ask questions and to have them answered.
- O I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without being disadvantaged in any way.
- O I understand that if I withdraw from the study then I will be offered the choice between having any data that is identifiable as belonging to me removed or allowing it to continue to be used. However, once the findings have been produced, removal of my data may not be possible.
- O I permit the researcher to use the video recordings that are part of this project and/or any other reproductions or adaptations from them, either complete or in part, alone or in conjunction with any wording solely and exclusively for (a) the researcher's portfolio; and (b) educational and examination purposes.
- O I understand that the video recordings will be used for academic purposes only and will not be published in any form outside of this project without my written permission.
- O I understand that identity of my fellow participants and our discussions in class is confidential to the group, and I agree to keep this information confidential.
- O I understand that any copyright material created by the video sessions is deemed to be owned by the researcher and that I do not own copyright of any of the photographs.
- O I agree to take part in this research.

Participant's signature: ....

Participant's name: ....

Participant's Contact Details (if appropriate):

....

....

....

....

Date:

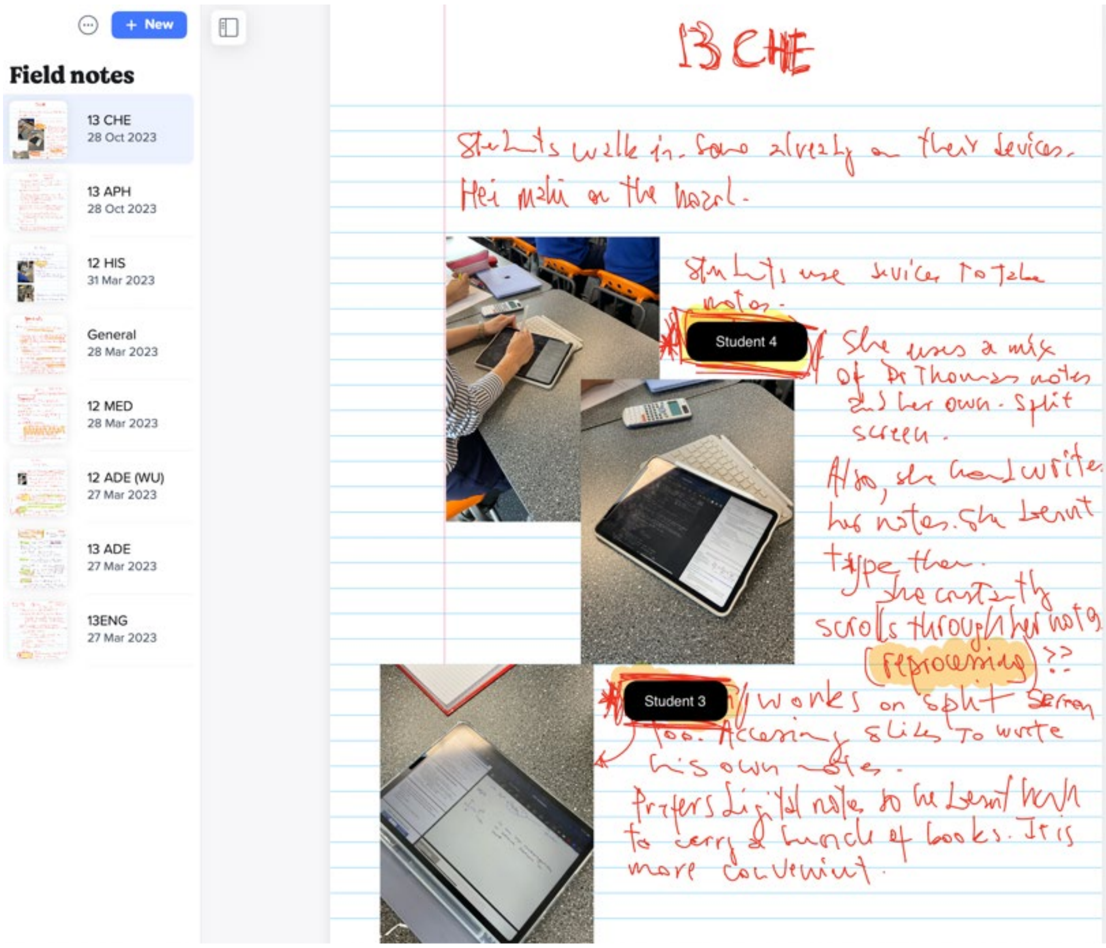
Approved by the Auckland University of Technology Ethics Committee on *26 July 2022*, AUTEC Reference number *22/114*.

Note: The Participant should retain a copy of this form.

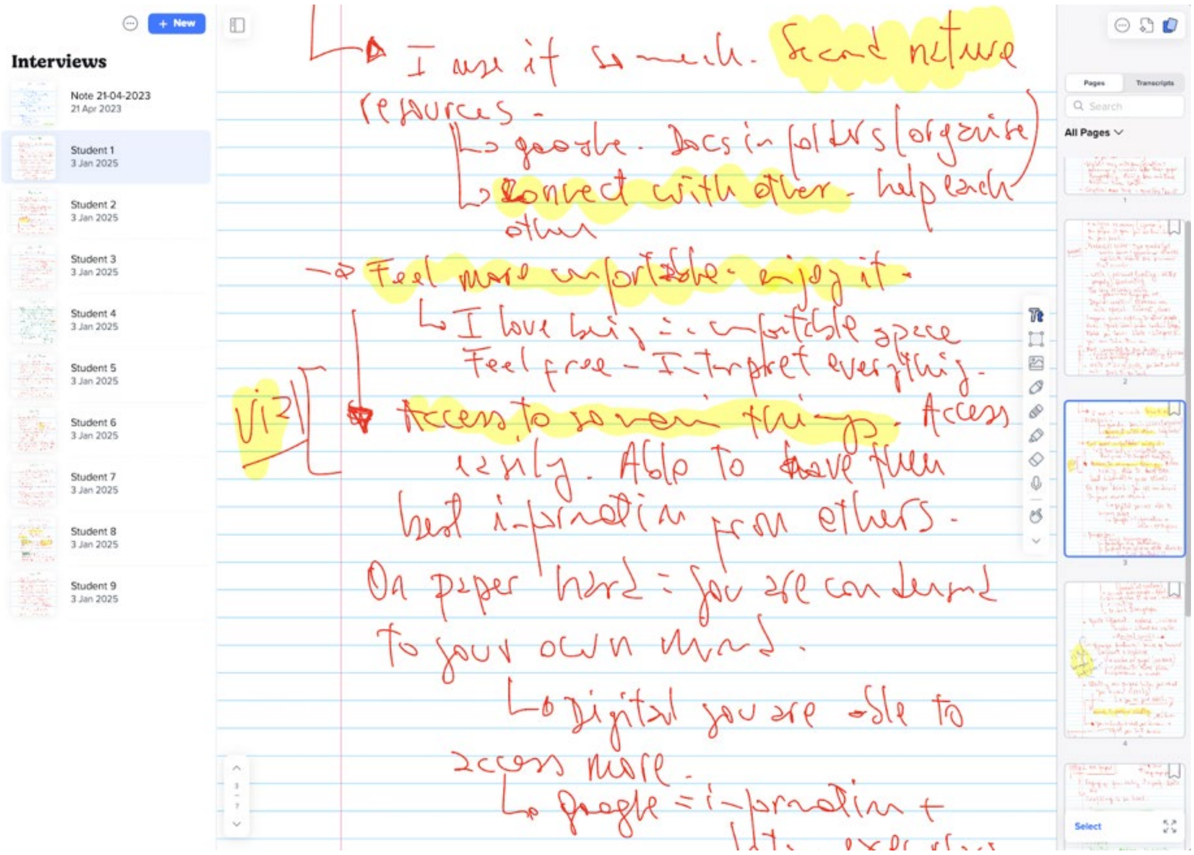
Appendix C: Sample of observations, coding and analysis

a. Observation notes

Observation notes were taken using Notability on iPad. The notes informed the research by (1) providing context; (2) informing the MPIs questions; and (3) serving to identify possible candidates for further participation.



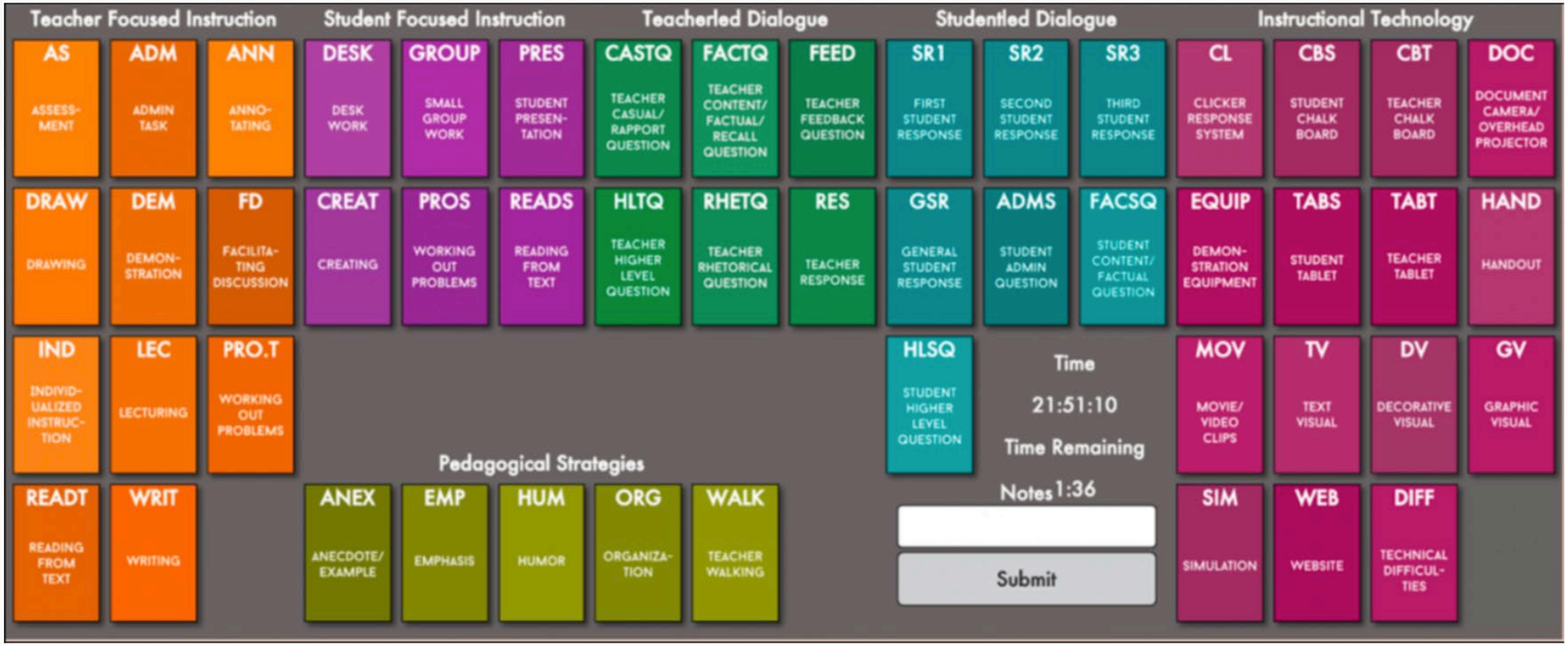
b. MPI notes



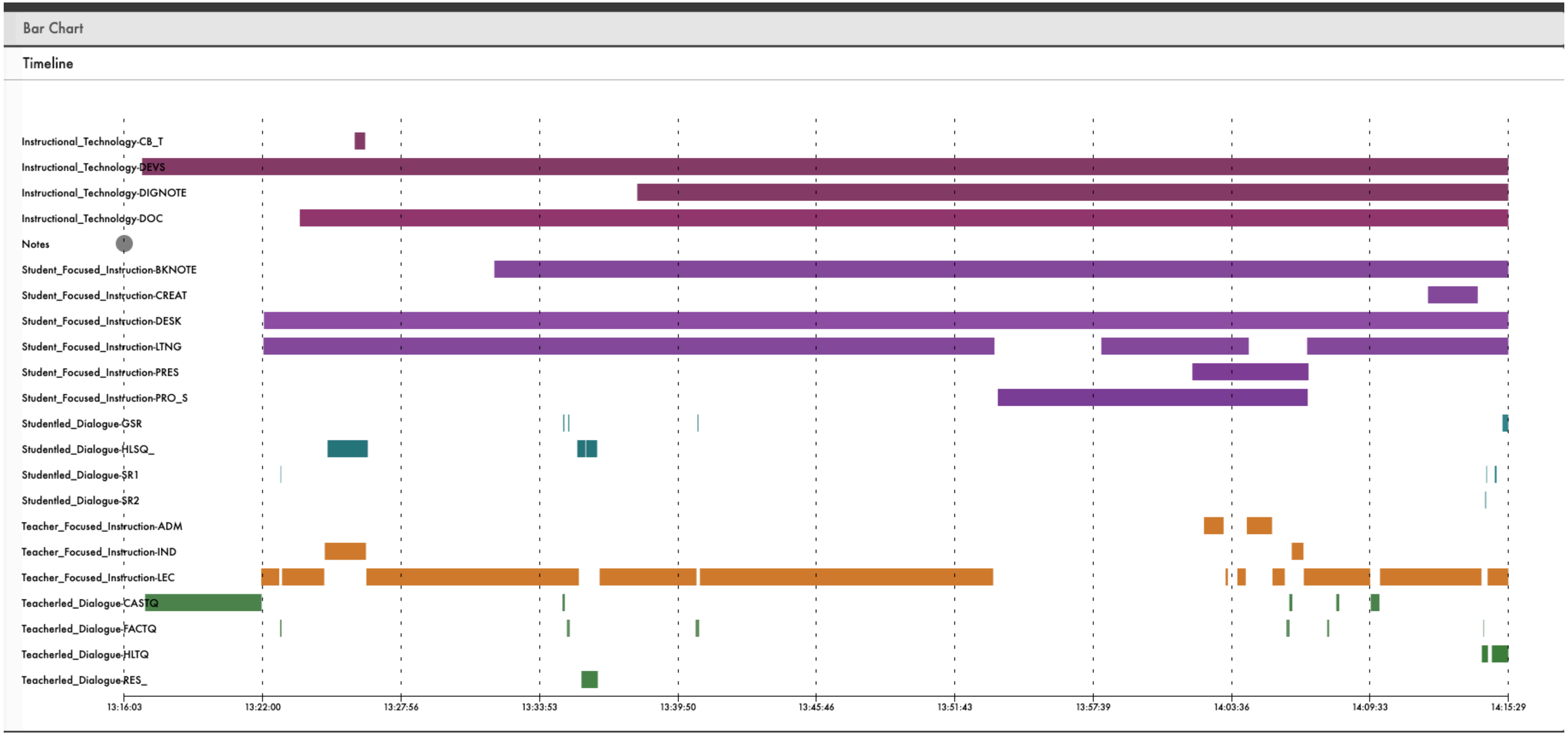
+ New
Interviews
Note 21-04-2023
21 Apr 2023
Student 1
3 Jan 2025
Student 2
3 Jan 2025
Student 3
3 Jan 2025
Student 4
3 Jan 2025
Student 5
3 Jan 2025
Student 6
3 Jan 2025
Student 7
3 Jan 2025
Student 8
3 Jan 2025
Student 9
3 Jan 2025
I use it so much. Second nature
resources -
google. Docs in folders (organise)
connect with other - help each other
Feel more comfortable - enjoy it
I love being in comfortable space
Feel free - Interpret everything.
Access to so many things. Access easily. Able to have the best information from others.
On paper hard: you are condemned to your own mind.
Digital you are able to access more.
google = information +
Pages
Transcripts
Search
All Pages
Select

c. General Observation and Reflection Platform (GORP)

GORP observation Dashboard



GORP observation report (single observation timestamp)

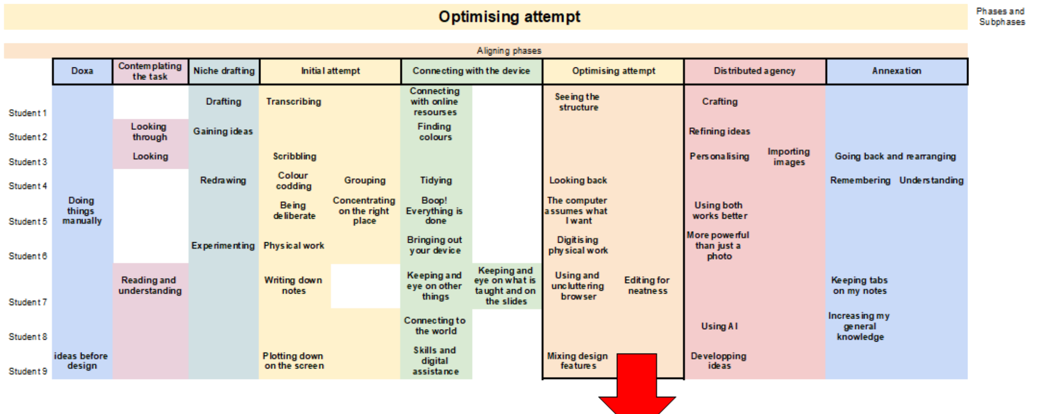


d. Micro Phenomenological analysis

Specific Diachronic Analysis (single experience)

				Iteration 1		Iteration 2		
Starting line number	**Finishing line number**	**Moments**	**Statement**	**Criteria**	**UDI**	**Moments**	**Criteria**	**UDI2**
39	40	1	well not exactly. Like **I was reading them** like **understanding them** and **writing my notes**	The statements speak about the information he accessed in GC	Reading and understanding GS	1a	Reading and understanding GS	reading and understanding
34	37	1	I had a so my teacher provides all of the slideshows and notes that he uses on a Google site and **I was on that Google** site **with the notes open** so that as he was explaining them, like I was **copying them down** and so that like he could go ahead and keep teaching well **I would catch up with a bit of the notes**			1b		catching up
47	49	2	I was I mean **I was copying the diagrams** for the reactions and mechanisms to produce the phenols and the reactions with the phenols and then **I was copying the different properties**. Well properties and the different forms of properties	The statements speak about what he was doing with his paper notes	Writing down notes	2a	Writing down notes	copying properties
51	51	2	into a **physical book**			2a		
39	40	2	well not exactly. Like I was reading them like understanding them and **writing my notes**			2b		writing my notes
53	57	2	yes just because **I feel like it's easier to do diagrams and stuff to supplement the writing** whereas on a computer doing diagrams is a bit harder with like without using like an iPad or something like that. mm-hmm but then like for other subjects like computer science I would really prefer not to but then sometimes we have to write code on our books which doesn't make sense			2c		doing diagrams
63	67	3	I was I mean **I always keep an eye on my emails** because sometimes in the middle of classes things come through and I have to so if it's not urgent I just see that I've gotten an email and it's fine but if it's like an urgent thing I have to quickly respond to I would I can be able to quickly respond to it but I think uh beyond that I wasn't doing much on my device Yeah	The statement spek about other things he was doing on his device	Keeping an eye on other things	3a	Keeping an eye on other things	emails
70	74	4	yeah but you also had his presentation he was using these slides on the board so with that so the thing is sometimes he that he says things quicker than I can like write them into my book so it's useful just to have that so **I can see exactly which slides I want to see** and then he can keep explaining and then **I can keep an eye on what he's teaching as well**	The statements speak about checking up information said by the teacher on the GC documentation	Keeping and eye on what is taught and what is on the slides	4a	Keeping and eye on what is taught and what is on the slides	find the right slide
188	192	4	it was definitely important [to have my device in class] because it meant that **if you missed something that you would have said I could like see exactly what he was trying to say** because like Dr Thomas is really good with this as a teacher like he tries to follow like his slides are around about what he's gonna say so **I can basically work out what he was saying** and obviously if I then couldn't figure it out I could always ask him			4b		work out what was said
112	113	5	not particularly but I think yeah the **the browser that I use made it really nice** to just because when I opened the slideshows like it wouldn't open it in a tab **it would open it in a pop-up**	The statements speak about the properties of the browser he was using	Using an uncluttering browser	5a	Using an uncluttering browser	pop-up opening
114	116	5	so that **I could quickly switch between the different ones** like if you like referenced something from an old presentation that I didn't think that I might have been away for **I could quickly like switch** to it really quickly can can you that's interesting			5b		navigating between elements
144	146	5	well it's like going between the different slides so arrow keys and clicking that to go to the next slide so with **within the pop-up you can actually Navigate to navigate** the slide yeah			5b		
147	149	5	and then in the **in the background of that pop-up would be what so behind the pop-up would still be the Google site and okay Excel w**ere you doing that as well in this particular lesson with the browser yeah because I I had to slide open as a pop-up as a pop-up yeah so the website never disappears			5c		keeping the same background
128	128	5	yeah because it means I **don't clutter up my tabs**			5d		dont clutter
156	158	5	which means that **it stays a lot more organized** because everything that you only need for that lesson only opens for that lesson and anything you need later you can like put as a tab so that you can use it later on			5d		
167	172	6	no matter how like much you try to keep them neat **there'll always be some cases where your notes just won't be as neat** whereas with a Google doc **you can go back and edit it as many times as you need** to make it like how you need it and as concise as you want it so you can **constantly keep editing** it whereas paper notes once you've written them you kind of either have to rewrite them if you want to make them neither or you have to like use white out and like write out a bunch of text	The statements speak about the impiortance of neatness.	Editing for neatness	6a	Editing for neatness	constant editing of notes
174	178	6	um **it's very important [that the notes are neat]** because as I'm going through past papers sometimes there might be a question that I've just forgotten how to do or like forgotten the concepts of and **it's just really important that I can go back** um well because I usually so once I've done with my digital notes this is the counter-intuitive but **then I print them out** and then so I have a physical copy next to me so then			6b		neat notes to go back to
183	183	7	so you keep tabs on your printed version of the book and that's **printed in like A5 booklet** so that's nice and small just on my desk	The statements spek about keeping tabs on his notes	Keeping tabs on my notes	7a	Keeping tabs on my notes	printing out notes
181	182	7	and you **just keep tabs on every like topic** and then you can just go right to that tab and you can just see exactly what what you need to know			7b		keeping tabs on topics
179	181	7	if I ever have an issueI can like **quickly flip to the right page** because since it's so short rather than my entire exercise book which is really big and then I have to like **find the right page** in that with a smaller book			7c		going to the right page

General Diachronic Analysis (group of experiences - fragment)

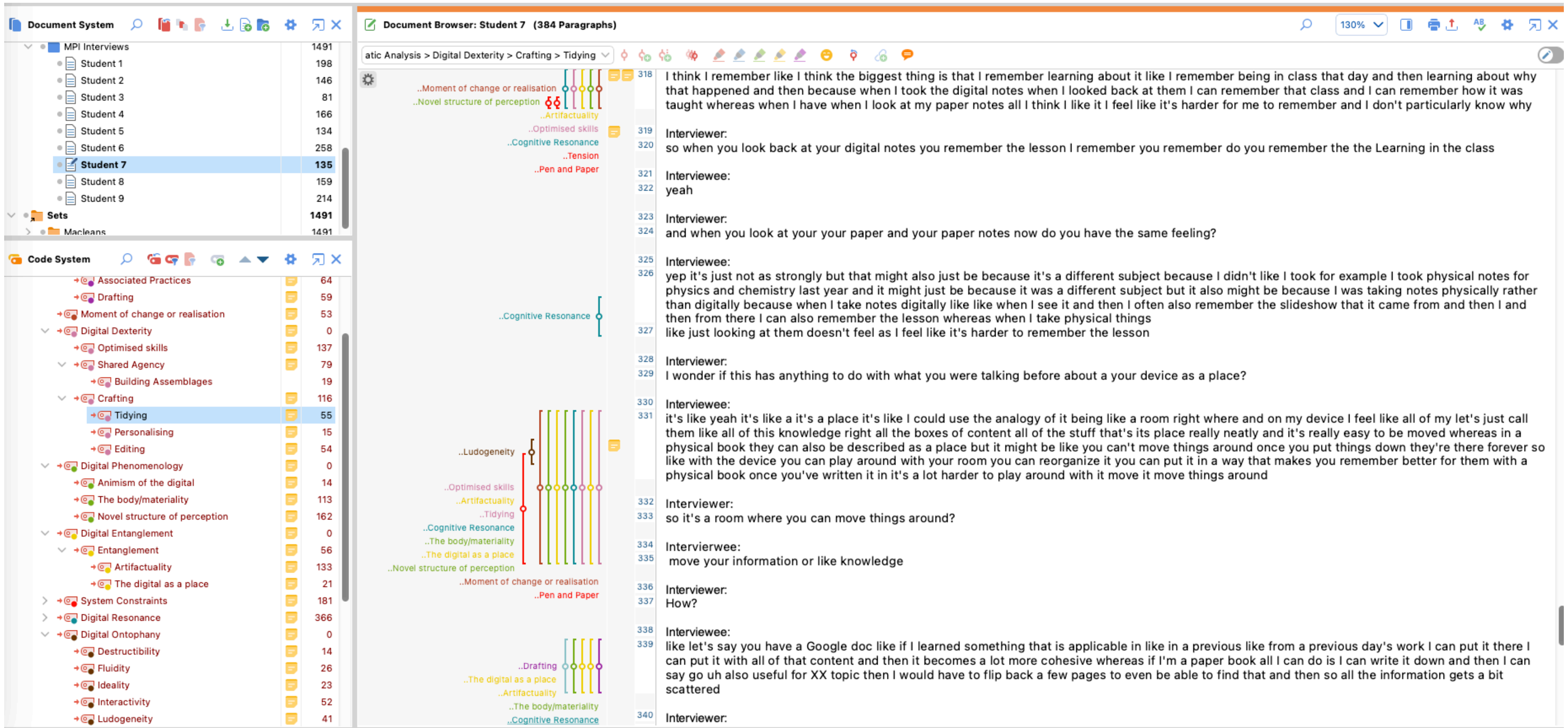


Optimising attempt

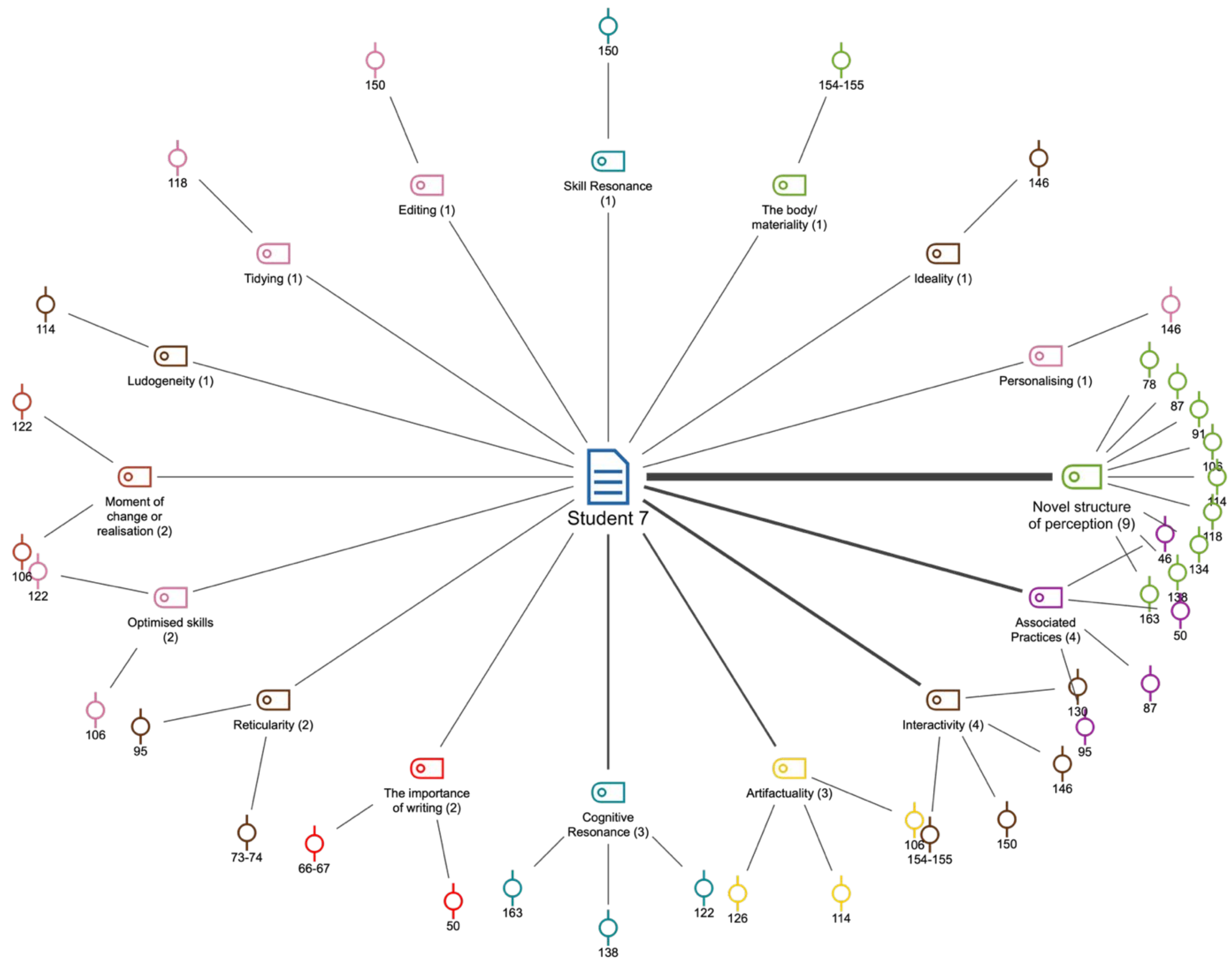
					Iteration 1			Iteration 2		Iteration 3			
WHO	Starting line number	Finishing line number	Moments	Statement	Criteria	UDI	Notes	Moments	Notes	Moments	Criteria	UDI	Sub UDI
Student 1	319	322	1	I just **see the structure**, which is the first thing mainly I saw.	The statements talk about seeing the structure		seeing	1a	seeing the structure	1a	Seeing a structure and ideas to be used	**Seeing the structure and features**	
Student 1	319	322	1	There was small paragraphs, and then I read through it **and saw the** tenses of it and **they didn't use too much "I" and "we"** and stuff like that. It was more inventive ones and carrying on each sentence with another sentence that links and then **linking the paragraphs** to each other as we			improving/evoq uing other ideas	1a		1a			seeing features
Student 9	467	467	1	it's a very visual thing um so **you get the idea by looking at these logos.**				1b	getting ideas	1a			
Student 6	158	158	4	it also helps me from **not being blocked**			improving/evoq uing other ideas	1b	getting ideas	1b			unlocking creativity
MC	151	152	2	and and I think it's very important that we kind of just it's kind of like just dumping **brain dump the stuff that we have onto the screen** so that we just have **different ideas visualized and saved** kind of on Photoshop			visualising different ideas	2a	dumping on the screen	2a	Improving work by switching to the device and starting a new process	**Starting a new process on the device**	
z	98	99	3	Okay, **we can improve on this when switching to a device.** Then from the device, **you can improve it vastly** and make it a lot better for the final submission.	The statements speak about using the device affordances		improving/evoq uing other ideas	2a	switching to the device to improve it	2a			dumping on the screen
MC	127	127	2	um but like yeah it's like it's like **a very physical thing** kind of **but we'll do it online**				2b	physical work done online	2b			physical online
MC	127	127	5	um but like yeah it's like it's like **a very physical thing** kind of **but we'll do it online**				4b	switching to the device	2b			
MC	151	152	5	and and I think it's very important that we kind of just it's kind of like just dumping **brain dump the stuff that we have onto the screen** so that we just have **different ideas visualized and saved** kind of on Photoshop				4b	switching	2b			
M	317	318	3	But since **I redrew it on my iPad**, I could **look at it easier** and look back at it				3a	versatile	3a	Working online and having more options and mixing features	**Expanding**	
K	132	133	4	I use digital photography because **it's just more versatile** and **ethically**, like bit **better**. I do want to experiment though with film so that probably is something that I will do.	The statements speak about the options and possibilities of using computers		versatile	3a	versatile	3a			versatility
K	151	153	4	if you're combining the both you can you know **you've got lots of options** instead of just taking photos so I think bringing in physical things um **expands what you can do** sort of thing			lots of options	3b	having options	3b			having more options
K	155	155	4	because you've got more **you have more possibilities** than just taking photos			options	3b		3b			
A	112	113	5	not particularly but I think yeah the **the browser that I use made it really nice** to just because when I opened the slideshows like **it wouldn't open it in a tab it would open it in a pop-up**	The statements speak about interacting online		interacting with the digital (in the sense of sensorimotor feedback)	3b	new visualisation	3b			
A	128	128	5	yeah because **it means I don't clutter up my tabs**			interacting with the digital (in the sense of sensorimotor feedback)	3b		3b			
MC	130	131	5	and like if we if **we mix both features** the way we do that is **through Photoshop** kind of **mix the two logos and you come up with a whole new idea** and				4c	mixing features	3c			mixing, layering and combining
K	145	145	7	and at the end I'll have **a digital photo of physical work** basically.			combining and layering	5a	digital physical	3c			
K	139	142	7	so it's sort of like I'm planning to **layer my designs** on top of photos so **I'm planning to combine** digital photos or film photos with physical work so that is like ripped paper, torn things, paint and things like that um because I **feel you can get more** emotion out of the physical side of it sort of thing. is that what you're asking?	The statements speak about layering and combining		combining and layering	5b	combining and layering	3c			
SF	322	323	4	I **see them as different** because one of them, it just have... **The computer does it for me**, whereas the other one, I **have to be in control of what happens.**			computer and I	4a	switching to the device	4a	Being in control of what happens	**Mixed control**	
K	318	323	5	which I can use to bring into more digital work and even if I might still use these in physical work it really depends on how I'm going because **with digital processes right you don't really have a plan** it just sort of happens so my my my photography and design this year will be very process based you'll only see the final design once I've finished it I won't have something planned it'll just basically coincidentally happen. so I find that that is probably the best way because it's it's real **it's it's it's it's organic** I guess you could say and			interacting with the digital (in the sense of sensorimotor feedback)	4b	digital unplanned process	4b			
z	85	87	2	Those **exemplars**, I was **able to structure it** and **understand what an excellent opinion piece** is. From there, I **use that structure to form my own opinion** piece.	The sytatements speak about using that structure that has been seen		Use that structure	1c	using that structure	6a	The statement talks about navigating, organising and reusing elemnts	**Use the structure to organise one's work**	
A	114	116	8	so that I could **quickly switch between the different ones** like if you like **referenced something from an old presentation** that I didn't think that I might have been away for **I could quickly like switch to it really quickly** can can you that's interesting	The statements speak about the properties of the digital		porperties	6a	quickly switching	6b			navigating
A	144	146	8	well it's like **going between the different slides** so arrow keys and clicking that to go to the next slide so with within the pop-up **you can actually Navigate** to navigate the slide yeah			new properties	6a	navigating	6b			
A	147	149	8	and then in the **in the background** of that pop-up would be what so **behind the pop-up would still be the Google site** and okay Excel were you doing that as well in this particular lesson with the browser yeah because I I had to slide open as a pop-up as a pop-up yeah so the website never disappears			mix mediums	6c	the background never dissappears	6b			

e. Micro Ethnographic Thematic Analysis

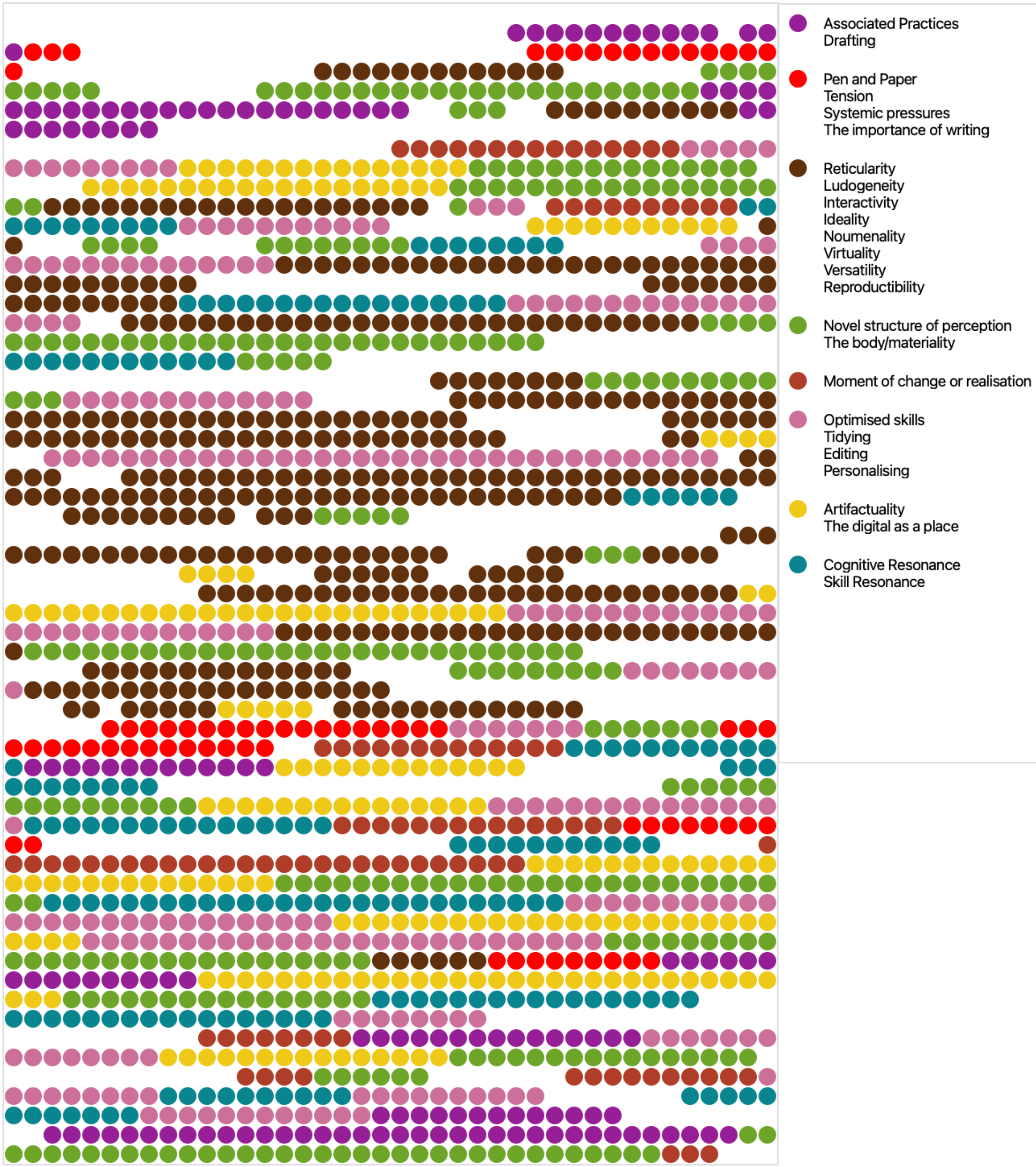
MAXQDA2022 coding (single document activated)



MAXQDA2022 coding (single case code map)



MAXQDA2022 coding (single case document portrait)



f. Code Matrix

MAXQDA2022 Code matrix (all codes-all documents)

Code System	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Student 9
Thematic Analysis									
Non-Digital/Initial Interventions									
Associated Practices		■	■	■		■	■	■	■
Drafting	■	■	■	■	■	■	■	■	■
Moment of change or realisation		■		■	■	■	■	■	
Digital Dexterity									
Optimised skills		■		■	■	■	■	■	■
Shared Agency	■	■			■	■		■	■
Building Assemblages			■	■	■	■			■
Crafting	■	■		■	■	■		■	■
Tidying	■		■	■	■	■	■	■	■
Personalising	■		■				■	■	
Editing	■	■	■	■		■	■	■	■
Digital Phenomenology									
Animism of the digital	■				■			■	
The body/materiality		■		■	■	■	■	■	■
Novel structure of perception		■	■	■	■	■	■	■	■
Digital Entanglement									
Entanglement	■			■		■		■	■
Artifactuality	■	■		■		■	■	■	■
The digital as a place	■		■	■	■		■	■	■
System Constraints									
Pen and Paper	■	■	■	■		■	■	■	■
Systemic pressures	■	■	■			■	■	■	■
Tension	■	■	■	■	■	■	■	■	■
The importance of writing		■	■	■	■	■	■	■	■
Digital Resonance									
Affective Resonance	■	■	■			■		■	
Cognitive Resonance	■	■	■	■	■	■	■	■	■
Skill Resonance	■	■	■	■	■	■	■	■	■
Digital Ontophany									
Destructibility		■	■			■			
Fluidity	■	■		■	■	■		■	■
Ideality	■	■	■		■		■	■	■
Interactivity	■	■	■	■	■	■	■	■	■
Ludogeneity	■		■	■		■	■	■	■
Noumenality	■	■		■		■	■	■	■
Reproductibility	■			■		■	■	■	■
Reticularity	■	■		■	■	■	■	■	■
Reversibility	■	■	■			■		■	■
Versatility	■			■	■		■	■	■
Virtuality	■	■	■		■	■	■	■	■

Appendix D: Glossary

a. Key Words and Definitions

A

Actor-Network Theory (ANT)

A theory that sees both humans and non-humans (like technology) as equally important actors in social networks. All actors shape what happens in the network.

Aesthetic School

The author's term for an alternative educational model characterised by:

- Vitalism and focus on ecological, embodied, and perceptual learning experiences
- Posthuman, post-digital sensibility rooted in extended, embodied, embedded, and enacted lived experience
- Recognition that both human and non-human aspects of education have agency
- Technology seen as constitutive of being-in-the-world rather than as external tools
- Learning through active engagement with digitally-mediated environments

Affordances

The opportunities for action that objects or environments provide. For example, a chair affords sitting, a door handle affords opening (Gibson, 1977).

Agency

The ability to act or make things happen. In this thesis, agency is shared between humans and technology rather than belonging only to humans. Understood as a relationship rather than something that someone has; a distributed effect within material webs where humans and non-humans act together to regulate activity (Barad, 2007; Fenwick, 2015). Leonardi (2023) defines it as the "capability to influence one's functioning and the course of events by one's actions" (Bandura, 2006, p. 164).

Agential Realism

Barad's (2007) theory that reality is made up of relationships and interactions, not separate objects with fixed properties.

Algorithmicity

Stalder's (2018) concept referring to automated decision-making processes that reduce and give shape to the glut of information.

Anaesthetic School

The author's term for traditional/current schooling characterised by:

- Education focused on transmission of knowledge rather than embodied experience
- Cognitive learning theories that privilege mind over body ("computer in the head" metaphor)
- Cartesian approach that separates mind and body
- Technology viewed as external tools to solve problems rather than constitutive elements
- Four key aspects: (1) Learnification of education, (2) symbolic understanding of cognition, (3) utilitarian view of technology, (4) Cartesian dualism

Animism of the Digital

The tendency for some digital platforms (particularly AI) to be seen both as tools and peers, attributing capacities to certain platforms as if they were capable of intentionality.

Annexation

The final phase in the generic diachronic hallmark where students speak about an exit and appropriation strategy after the resolution of the task.

Artefactuality

The process of creating artefacts (human-made objects) that become part of cognitive processes and are fed back into the environment, affecting both organism and environment. In this thesis, also refers to one of three properties of digital artefacts (along with Explorability and Nomadicity).

Attentional Anchors

Mechanisms used to focus attention during learning by coupling action with perception, reducing complexity through motor action (Hutto & Sánchez-García, 2015).

Autopoiesis

The ability of living systems to maintain and recreate themselves. Developed by Maturana and Varela (1974) to explain how organisms stay organised and continuously produce their own components.

Axiological Self
One of the "Two Selves" representing values and principles about what good education is. Often associated with analogue approaches that align with institutional values and traditional good practice.

B

Being-in-the-world (Dasein)
Heidegger's (1927/1996) idea that humans are always already engaged with their environment, not separate observers looking at the world from outside. We are always situated in particular contexts.

Biocultural Coevolution
The process where biological and cultural factors influence each other's development over time through feedback loops.

Brainbound Model
Clark's (2008) term for the idea that thinking happens only in the brain, treating the body and environment as unimportant. This thesis argues against this view.

BYOD (Bring Your Own Device)
An organisational approach where devices are owned and managed by their users rather than the institution.

C

Cartesian Dualism
René Descartes' idea that mind and body are completely separate substances. The mind (res cogitans) thinks but has no physical presence; the body (res extensa) is physical but cannot think. This creates an internal vs external world distinction.

Causal Closure of Physics (CCP)
The concept that everything happening in the physical world is caused by other physical things, meaning the laws of physics are present in all explanations. Digital phenomena may operate outside these constraints.

Cognitivism

The dominant paradigm in cognitive science that views the mind as working like a computer, processing symbols and making internal representations of the external world.

Cognitive Projection

Malafouris' (2013) concept of the unconscious ability to establish direct connections between different domains of experience, allowing material objects to anchor conceptual thinking.

Cognitive Tools

Objects or systems that help us think better and become integrated into our cognitive systems. Three types: (1) symbolic tools (writing, computer languages), (2) sensory tools (microscopes, telescopes), (3) tracking tools (rulers, GPS) (Menary, 2023).

Communality

Stalder's (2018) concept describing a collectively shared frame of reference through which meanings can be stabilised, possible courses of action can be determined, and resources can be made available.

Computational Theory of Mind (CTM)

The central hypothesis of cognitive science that the mind operates through mental representations and computational procedures operating on those representations.

Conatus

Spinoza's (1663/2020) term for the effort that all living things make to continue existing and flourishing - the power of life to preserve itself.

Connecting with the Device

Fourth phase in the generic diachronic hallmark where students begin to engage with their digital device, recognising its potential to assist with the task.

Constructability

One of three properties of digital artefacts (along with Explorability and Nomadicity). Digital objects can be constructed, copied, cloned, and reproduced in ways that physical objects cannot.

Constructivism

Learning theory emphasising that learners actively construct knowledge through experience and interaction with their environment.

Contemplating the Task

Second phase where students survey and recognise the elements constituting the task ahead.

Correspondence

Ingold's (2013) idea that we learn by moving and responding together with our environment, like a conversation between ourselves and the world - coupling our movements with the becoming of materials.

Crafting

Process of editing, refining and perfecting work, often done digitally. Involves tidying, editing, and personalising content.

Cultural Epicycles

Modifications to environmental niches caused by human activity (rather than external forces), creating new constraints and affordances that feed back into the environment (Tomlinson, 2015; 2017).

Cybernetics

A multidisciplinary movement that aimed to unify approaches across sciences through a consolidated systems theory, influencing early cognitive science.

D

Dasein

Heidegger's term meaning "being-there" - the idea that human existence is always situated in a particular place and time with specific cultural and historical contexts.

Deutero-learning

Bateson's concept of learning how to learn - a kind of learning that allows humans to be taught by the world.

Dexterity

The skilled ability to move and act effectively in an environment by overcoming excessive degrees of freedom. Not just physical skill, but the ability to adapt to changing situations and select appropriate movements (Bernstein, 1967).

Diachronic Analysis

Looking at how an experience unfolds over time, step by step - the temporal dimension of experience.

Diffraction

A method for reading different sets of data together to create new insights, like waves creating new patterns when they meet. Used to analyse texts or data through each other (Barad, 2007).

Deep Learning

Learning that involves more than abstract understanding, knowledge accumulation, or skill development. Characterised by an intention to understand and impose meaning (Marton & Sääljo, 1976), focusing on effortful practice and lived experience (Bennet & Bennet, 2008). Requires understanding, meaning, and integration that shifts one's frame of reference as the context shifts.

Digital Dexterity

The cascading form of resonance that develops as students become skilled at navigating digital environments. A series of manoeuvres within digital structures of perception that enable skilful response to and within them.

Digital Entanglement

The complex relationship between students and their digital devices where they become interconnected and shape each other, creating potentials, investments, and entrapments. The system of engagements and hybridities between users and their digital devices.

Digital Ontophany

How digital technology changes the way we perceive and experience reality itself - the phenomenological revolution brought by digital technologies (Vial, 2019).

Digital Phenomenology

A particular way of experiencing the world that results from digital manipulation - how things appear or are perceived in a digital context.

Digital Resonance

A particular way in which students resonate with their digital devices at affective, cognitive, and skill levels.

Distributed Agency

The concept that agency is shared across humans, technologies, and environments rather than being contained within individuals.

Distributed Cognition

The idea that thinking and knowing are spread across individuals, tools, and representations rather than being contained within individual minds.

Doxa

The first phase in the generic diachronic hallmark where statements speak about the cognitive state before engaging with the task.

Drafting

The first overarching moment in the hallmark of the experience, characterised by an organic, free-style approach; often unassisted and manual, where initial ideas are concatenated without concern for exactitude or coherence.

Dwelling

Ingold's (2000/2021) concept of actively engaging with and inhabiting our environment, building relationships with the world around us through skilled engagement.

E

Ecological Psychology

Gibson's (1977) theory that organisms directly perceive affordances (opportunities for action) in their environment without needing internal representations.

Embodied Cognition

The idea that thinking involves the whole body, not just the brain. Our physical experiences and sensorimotor patterns shape how we understand the world and guide action.

Embedded Cognition

The view that cognitive processes are deeply dependent on the environment in which they occur.

Enacted Cognition

The idea that cognition arises through dynamic interaction between an organism and its environment, emphasising the role of action in perception.

Enactivism

The theory that thinking and perceiving happen through actively engaging with the environment. Three main branches: autopoietic (Di Paolo, 2005), sensorimotor (O'Regan & Noë, 2001), and radical enactivism (Hutto & Myin, 2012). Emphasises the continuity between life and mind.

Enculturation

The process by which humans acquire cultural tools and practices that become integrated into their cognitive systems, transforming how they think and act.

Entangled Body Readiness

The embodied dynamics that emerge from digital entanglement - a form of skilled intentionality adapted to digital environments. Represents patterns of body readiness developed through digital interaction.

Entanglement

When different things become so interconnected that they cannot be separated or understood independently. They emerge together and shape each other through dependences and dependencies (Hodder, 2012).

Episteme

Foucault's (1971) term for the underlying knowledge system that defines what can be known and how in a particular time and place - the conditions of possibility for knowledge.

Epistemic Actions

Clark and Chalmers's (1998) concept of actions that enhance cognitive functions rather than directly changing the world (contrasted with pragmatic actions).

Epistemology

The study of knowledge - how we know what we know and what counts as valid knowledge.

Ethnography

A research method that studies people's cultures and practices by observing them in their natural environments over extended periods.

Explorability

One of three properties of digital artefacts. Digital objects are interconnected, interactive, and playful (ludogeneic), inviting exploration and sense-making through their networked nature.

Extended Evolutionary Synthesis (EES)

A framework expanding traditional evolutionary theory to include additional mechanisms like niche construction and developmental plasticity.

Extended Mind

Clark and Chalmers's (1998) theory that thinking extends beyond the brain to include tools and environment. External elements can become genuine parts of cognitive processes when they meet certain criteria.

F

Field of Affordances

Rietveld's concept of the relevant opportunities for action as experienced by a particular individual in a specific situation, contrasted with the broader landscape of affordances.

Field of Promoted Action

Reed and Bril's concept of how culture creates selective opportunities for action, promoting certain motor skills and affordances over others.

Flat Ontology
The idea that all entities (humans, animals, objects, technology) exist on the same level, rather than humans being more important than everything else. No pre-given hierarchies exist.

Fluidity
One of Vial's dimensions of digital ontophany. Digital manipulation appears light, immediate, simple, and magical - everything seems to glide and happen effortlessly.

G

Generalised Symmetry
Actor-Network Theory principle of treating humans and non-humans as equally important actors in social situations.

Generic Diachronic Hallmark
The common pattern of experience identified across multiple participants in micro-phenomenological analysis, showing eight phases from Doxa to Annexation.

Generic Hallmarks
Common, shared features of experiences across different individuals in micro-phenomenological analysis, revealing patterns that transcend individual differences.

Graphical User Interface (GUI)
The visual way we interact with computers using windows, icons, menus, and pointers. Dominated by two-dimensional WIMP (windows, icons, mice, pointers) interactions.

Gutenberg Galaxy
McLuhan's term for the model of society produced by changes brought about by the advent of the printed book.

H

Habitus
Pierre Bourdieu's concept of learned habits and ways of acting that shape how we behave in different situations.

Hallmarks

Term used instead of "structure" to preserve the dynamic nature of experience in micro-phenomenological analysis. Refers to the characteristic patterns of experience.

Hermeneutic Phenomenology

Heidegger's approach to phenomenology that sees understanding as an existential process of interpreting being-in-the-world.

Humanism

The philosophical tradition that puts humans at the centre of everything, emphasising human exceptionalism and the capacity to transform the environment. Sees humans as separate from and superior to nature and technology.

Hybrid Assembly

Malafouris's term for the emergent meaning that arises when physical relations serve as proxies for conceptual relations in material engagement.

Hypergrip

Rietveld's term for a zone offering wide range of action opportunities and possibility to flexibly switch between behavioural patterns.

I

Ideality

One of Vial's dimensions of digital ontophany. Digital phenomena are programmable and synthetic - a patchwork of compilers.

Industrial School

The traditional model of schooling that emerged during the mechanical technological system, characterised by standardised schedules, mass education, and Fordist principles.

Information Processing Theory

Cognitive theory that views the mind as processing information through stages, similar to how computers process data.

Initial Attempt

Third phase in the generic diachronic hallmark where students speak about the first proper exploration of affordances and plotting of the extended task.

Intentionality

In phenomenology, the idea that consciousness is always directed toward something. We're always conscious *of* something. Can be prior intention (mental state) or intention in action (action in the world) (Merleau-Ponty, 1945/2012; Searle, 1983).

Interactivity

One of Vial's dimensions of digital ontophany. Not a direct body action but an interaction with a system interface.

Intra-action

Barad's term for how things influence each other from within relationships, rather than acting on each other from outside. The mutual constitution of relata within phenomena.

Intra-active Pedagogy

Lenz-Taguchi's approach that shifts attention from intra-personal and inter-personal relationships toward interdependent relationships between people and material environment.

L

Landscape of Affordances

Rietveld's concept of the many opportunities for action available in a particular form of life or ecological niche.

Learnification

Gert Biesta's (2015) term for reducing all of education to just "learning" and measuring outcomes, ignoring other important aspects like socialisation and subjectification.

Lived Experience (Erlebnis)

How life feels from the inside - your personal, subjective experience of being in the world. Both what one experiences and its lasting residue.

Ludogeneity

One of Vial's dimensions of digital ontophany. Digital interfaces promote a playful, exploratory attitude even when they are not designed as games.

M

Material Agency

The idea that objects and artefacts are not passive but actively participate in cognitive processes and have effects in the world.

Material Anchoring

The use of external, manipulable structures to support cognitive projection and meaning-making.

Material Ecology

Ingold's term for studying the mind in context, emphasising the material relationships that constitute thinking.

Material Engagement Theory (MET)

Malafouris's theory that thinking happens through our interactions with physical objects and tools, not just inside our heads. Based on three hypotheses: extended mind, enactive sign, and material agency.

Material Semiosis

The process by which material objects create meaning through enactive logic rather than communicative logic - meaning emerges from engagement, not representation.

Mechanical Technological System

Vial's term for the technological system characterised by mechanisation to offload physical effort, which lasted until the rise of digital technologies.

Mediation

Vygotsky's (1978) concept that humans use tools and symbols (mediating artifacts) to indirectly influence their environment and organise their thinking.

Micro Ethnography

A research method that studies small-scale social interactions and practices in detail, focusing on bodily communication, gestures, and interactions with artefacts.

Micro Phenomenology

A research method that helps people describe their lived experiences in fine detail, focusing on how experiences unfold moment by moment from the first-person perspective.

Micro-Phenomenological Interview (MPI)

A structured interview technique designed to help participants access and describe singular concrete experiences in detail, avoiding generalisations.

Monism

The philosophical view that reality is one unified substance, rather than being split into separate mind and body parts. Spinoza's alternative to Cartesian dualism.

Motor Control

The study of how organisms control and coordinate movement, involving the dynamic relationship between proprioception and exteroception.

N

Narrative Analysis

A research method that analyses stories people tell, focusing on structure, content, or performative function to understand meaning-making.

NCEA (National Certificate of Education Achievement)

The main school certificate in Aotearoa New Zealand, introduced progressively from 2002 as a multilevel qualification.

Neurophenomenology

Varela's approach that bridges neuroscience and phenomenology by studying both brain processes and first-person experience.

Niche Construction

How organisms actively change their environment, which then influences their own development and evolution.

Nomadic Subject

Braidotti's concept of the posthuman subject as constantly moving and becoming, situated in specific contexts but not fixed to them.

Nomadicity (Artefactuality)

One of three properties of digital artefacts. Digital objects can move, change, and be reshaped as they enter different contexts - they exist in different places and no-place in particular.

Noumenality

One of Vial's dimensions of digital ontophany. Digital phenomena exist outside direct experience and can only be accessed through interfaces.

O

Ontology

The study of what exists and the nature of reality - what is real and how things exist.

Onto-epistemology

Barad's approach that combines questions of being (ontology) and knowing (epistemology) as inseparable. Doing, being, and knowing are integrated.

Ontophanic Matrix

A general structure of perception created by technological systems that determines what can appear and be experienced in reality.

Ontophany

How technology shapes what can appear and be experienced in reality - how beings (ontos) appear (phaino) through technological mediation (Vial, 2018).

Optimal Grip

Merleau-Ponty's concept of the tendency in skillful activity to find equilibrium with the situation through embodied responsiveness.

Optimising Attempt
Sixth phase where students engage in more in-depth work with their devices, representing the core moment of digital entanglement.

Organic User Interface (OUI)
Non-planar interfaces that take any 3D shape and can morph to support direct physical interaction.

P

Paradigm
Kuhn's (1962/2012) term for universally recognised scientific achievements that provide model problems and solutions for a community of practitioners.

Parity Principle
From Extended Mind Theory - if an external tool functions the same way as an internal mental process and meets certain criteria, it should be considered part of the mind.

Performativity
The idea that reality is created through ongoing actions and practices, rather than existing independently beforehand. Focus on doing rather than representing.

Phenomenological Bubble
A customisable digital mini-ecosystem that is highly responsive to users' needs and preferences, created through digital interaction.

Phenomenological Revolution
Vial's term for how digital technologies modify our act of perceiving, affecting perceptual culture itself.

Phenomenology
The study of conscious experience as experienced from the first-person point of view - the study of phenomena as they appear to consciousness.

Posthumanism
A philosophical movement that challenges human-centred thinking and recognises the agency

and importance of non-human entities. Emerges from anti-humanism and anti-anthropocentrism.

Postdigital
The condition where digital technology is so embedded in life that it is no longer noticed as separate or special. Can refer to disenchantment with digital gadgets or normalisation of digital intrusion.

Postdigital We-Learn
Jandrić and Hayes's concept of collective learning that acknowledges relationships between humans and machines in shared meaning-making.

Pragmatic Effect
Malafouris's concept of how intention is realised in the world through actual practice and being-in-the-world, not just private thought.

Praxeological Self
One of the "Two Selves" representing practical considerations about accomplishing tasks effectively. Often associated with digital approaches that prioritise getting things done.

R

Referentiality
Stalder's (2018) concept referring to the use of existing cultural materials for one's own production.

Relational Ontology
Barad's approach where entities emerge through relationships rather than having pre-existing properties. Things exist in phenomena, not independently.

Representationalism
The idea that the mind creates internal pictures or models of the external world. Separates the world into words and things. This thesis argues against this view.

Reproducibility
One of Vial's dimensions of digital ontophany. Digital objects can be copied instantly and infinitely without loss of quality.

Resonance
In ecological psychology, how organisms tune in to information in their environment without computing or representing it internally. A coupling between dynamic systems at different scales (Raja, 2018).

Reticularity
One of Vial's dimensions of digital ontophany and a key concept in this thesis. The networked, interconnected quality of digital environments that shapes social reality and creates new forms of connection.

Reversibility
One of Vial's dimensions of digital ontophany. Digital processes can be undone, cancelled, or restarted, offering a "control-Z" mindset that transcends the irreversibility of the physical world.

S

Schema Theory
Anderson and Pearson's theory that knowledge is represented schematically, with propositions as the basic unit comprising all schemata.

Self-Organised Criticality
The tendency of systems to organise themselves in ways that allow rapid transitions between different patterns.

Sensorimotor Contingencies
O'Regan and Noë's concept of the relationship between sensory input and motor actions that enables perception and the use of environment as external memory.

Sentient Ecologies
Ingold's term for the skills, sensitivities, and orientations that develop through long experience within a particular environment.

Skilled Intentionality Framework (SIF)
Erik Rietveld's theory about how skilled people respond appropriately to opportunities (affordances) in their environment through body readiness.

Social Brain Hypothesis (SBH)
The theory that human cognitive abilities evolved primarily to deal with social complexity.

Socio-Material
Approaches that study the entanglement of social and material aspects, recognising that they emerge together rather than being separate domains.

Spherology
Sloterdijk's concept of how humans create and inhabit symbolic and biotechnical spaces that enable human flourishing.

Structural Coupling
Maturana's concept of how organisms and environment become mutually adapted through ongoing interactions.

Subjectification
Biesta's term for the process of becoming an independent, unique subject - one of three dimensions of education alongside qualification and socialisation.

Synchronic Analysis
Looking at the structure and characteristics of a single moment in an experience, examining structural features rather than temporal unfolding.

T

Tale of Two Schools
Foundational metaphor contrasting the Anaesthetic School (traditional) with the Aesthetic School (digital/embodied), representing clashing paradigms in education.

Tale of Two Selves
Extension of the Two Schools metaphor describing how students navigate tension between different approaches by performing different versions of their identity.

Tangible User Interface (TUI)
Interfaces that couple digital information with physical objects, making digital bits tangible and manipulable.

Technical Combination
Gille's first level of technological systems - the intelligent coupling of energy and matter.

Technical Concatenation
Gille's third level of technological systems - products that emerge after a series of production stages.

Technical Ensemble
Gille's second level of technological systems - where techniques combine in particular production processes.

Technological Systems
Integrated networks of technologies, practices, and social arrangements that shape how people perceive and act in particular historical periods. Create ontophanic conditions.

Te Mātaiaho
New Zealand's curriculum framework integrating "Understand, Know, Do" to ensure deep and meaningful learning. May unintentionally promote digital entanglement.

Tension
The experience students feel when navigating between different approaches to learning, resolved through selecting either axiological or praxeological strategies.

Thematic Analysis
Method for developing, analysing and interpreting patterns across qualitative data through systematic coding processes.

Things-in-Phenomena
Barad's concept that objects do not have independent properties but emerge through relational interactions within phenomena.

Transcendental Phenomenology

Husserl's approach that grounds phenomenology in transcendental consciousness to achieve scientific understanding.

Triangulation

Using multiple sources of data or methods to increase the reliability of research findings. Four types: data, investigator, theory, and methodological.

U

Ubiquitous Computing

The vision of computing being embedded everywhere in the environment, making it invisible and natural to use. Weiser's prediction of computing access being everywhere.

Umwelt

Jakob von Uexküll's (1934/2013) term for the perceptual world that an organism lives in and acts within - how the environment appears to that particular organism.

Unity of the Flesh

Merleau-Ponty's concept of the fundamental connection between body and world that contradicts Husserl's egology.

V

Versatility

One of Vial's dimensions of digital ontophany. Instability - living with the potentiality of 'bugs'.

Vial's Dimensions of Digital Ontophany

Eleven categories that define digital ontophany: (1) Noumenality (virtual phenomena only perceivable through interfaces), (2) Ideality (programmable, synthetic), (3) Interactivity (interaction with system interfaces), (4) Virtuality (capacity to create simulated realities), (5) Versatility (instability, living with 'bugs'), (6) Reticularity (networked social reality), (7) Reproducibility (instant, infinite copyability), (8) Reversibility (cancelability), (9) Destructibility (prone to disappear), (10) Fluidity (light, immediate, 'magical'), (11) Ludogeneity (playable, explorable).

Vicarious Learning

Bandura's concept of learning through observation rather than direct experience.

Virtual Reality (VR)

Technology that creates immersive virtual worlds that users can see and interact with.

Virtuality

One of Vial's dimensions of digital ontophany. The capacity of graphical interfaces to create simulated realities.

Vygotsky's Zone of Proximal Development

The difference between what a learner can do alone and what they can do with help from others - the space where learning occurs (Vygotsky, 1978).

Note: This glossary focuses on terms as they are used within the context of this thesis. Some terms may have different meanings in other academic fields or contexts.