

The A-Z of Creative Technologies

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Abstract

This paper undertakes an initial critical analysis of Creative Technologies as a means to gain insight to the nature of this as an emerging field. The paper utilises an approach previously used in the design discipline to characterise the field through the embodiment of an alphabetised narrative. This is extended through an analysis of the inter-relationships between the identified elements. The outcomes of this work are useful both in terms of identifying outcomes of academic programmes related to Creative Technologies and also stimulating a wider debate around the nature of the field.

Keywords: creative technologies, education, graduate outcomes, pedagogy.

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1. Introduction

The term “creative technologies” in many ways defies a formal definition. In a modern context, it refers to the integration of knowledge and practices from a variety of disciplines that include Art, Computer Science, Design, Engineering, and the Humanities. In education, graduate profiles from degrees of this ilk are typically oriented to imaginative synthesis across other established and more rigidly defined disciplines. The lack of a universal definition is a challenge in terms of understanding what is (and what is not) in scope of creative technologies. This also presents a challenge as the field rapidly changes and new technologies and practices emerge alongside a growing interest-group based in academia, community and industry. Indeed, some authors suggest that creative technologies are going to be a driving force in changing the world [1].

The emergence of creative technologies as a recognised field bears some similarity to the history of the design disciplines, which have gone through a number of phases in terms of balancing practice with method [2]. This extends to the present day with a view that design transcends disciplines rather than being a discipline in its own right [3]. However, unlike design, there is a current lack of critical analysis on the

nature of creative technologies with only a few attempts to explore the “nature of the beast” [1, 4-6]. An opportunity therefore exists to formulate a dialogue amongst educators, practitioners and researchers in this field to support such critical analysis.

This paper draws inspiration from the work of Rogers and Bremner [7] who provide insight to design through the consideration of an “A to Z” view of the characteristics of contemporary design. By emulating that structure, this paper does not attempt to be a definitive statement of what is the scope of creative technologies, but instead seeks to present a “straw man” in order to help shape conversations on the identity and qualities of this emerging field. As such, it is intended to provoke discussion and to be re-imagined and re-created by others in the international arena to generate some common ground from which creative technologies may emerge as a discipline, a meta-discipline, or a mode of thinking about and transforming the contemporary world.

The rest of this paper is organised as follows. Section 2 provides a brief overview of the method used to generate the descriptive labels that describe Creative Technologies. Section 3 outlines the “dictionary” developed using this method. Section 4 provides a reflective discussion on the content and Section 5 concludes the paper.

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2. Development Method

The main content of this paper was developed using an iterative, reflective, and collaborative approach where concepts were proposed, their descriptions considered, and mapped to each other to identify similarities. An early version of this list resulted in many similar terms, i.e., *bricolage*, *hacking*, *making*, and *undisciplined* were identified as related terms. A discursive and reflective process was used to identify terms that could be collapsed into more comprehensive terms in order to increase conceptual scope, clarity, and inclusiveness. Of special importance in this process was the use of thesaurus and lexical databases to navigate the conceptual linkages between terms in English.

In addition, the terms were also mapped to the graduate profile and learning outcomes of a Creative Technologies degree programme to identify gaps. As terms were examined and collapsed, idea generation techniques were used to propose new concepts. This process was conducted using a tangible format, namely flash cards that could be sorted, amended, and annotated, in order to elaborate upon each concept and to clarify a shared understanding of the intention of each gloss. A number of such cards from the first iteration are shown in Figure 1.

<i>Collaborative (Language)</i>	<i>Futurists</i> <i>Speculative</i>
<i>QUIXOTIC (PLAYFUL)</i>	* <i>Discovery</i> <i>LANGUAGE</i> <i>Learning</i> (<i>reflection</i>)
<i>PROBLE</i> <i>PLAYFUL</i> <u><i>PROBLEMS.</i></u>	<i>Craft</i> <i>Making</i> <i>Hacking</i> <i>Skills</i>

Figure 1. Development Flash Cards

The annotation strategy is illustrated with the concepts *quixotic* and *playful* which were collapsed and reframed, as both pointed to the inquisitive and curiosity-driven way in which practitioners approach technology in this area. These terms led to the mid-19th century adjective *wacky*, a derivation of the noun *whack*, a “try or attempt” and derivationally related to *eccentric* and *unconventional*. In two

cases, the quest for terms and the ensuing dialogue extended into the manuscript review stage, with one anonymous reviewer suggesting the term *wicked* rather than *wacky* to better capture the idiosyncratic nature of problem-solution pairs in this field. This type of rich deliberation reinforces the nature of our work to present a “straw man” that helps shape conversations, rather than to pursue conclusive definitions.

The process of identifying gaps and mapping concepts to the curriculum of the programme can be illustrated with the annotation of *futurists*, a term that led to the insight that speculative design projects tend to be included in the first year of the undergraduate programme to highlight the critical differences between predicting the future and the speculative synthesis of possible futures. In total, it took two iterations to reach an initial consensus and in each iteration there was detailed consideration and extended deliberation of the inter-relationships between all terms.

The development process was undertaken by the authors themselves, both of whom are active in teaching and research related to Creative Technologies. The two iterations of development spanned several weeks with several face to face discussions lasting a few hours each. In total, the process considered over a hundred possible concept terms for inclusion in this paper. The initial review of the paper also led to refinement of the terms based on observations from the reviewers. Two terms were changed as a result, essentially leading to a third development iteration that is not formally described.

The final set of concepts was agreed upon using a combination of idealistic and pragmatic strategies. It is acknowledged that the alphabetic structuring is both abstract and artificial, hence certain terms (for example the letters Q, X and Z) were considerably problematic due to there being a smaller number of possible words or concepts to choose from. The agreed set of terms presented in section 3 represents a corpus from which future research can identify key themes or ideas that can be removed from the initial artificial structure used to stimulate debate and discussion.

3. The A to Z of Creative Technologies

The following sections make explicit the views of the authors on how the field of creative technologies can be characterised in order to provide a better understanding of the nature and identity of the creative technologies to differentiate it from other disciplines and fields of practice.

3.1. A is for... Adaptable

Zagalo and Branco [1] suggest that “Creative technologies have always been the basis for human expressivity: to sustain self-realization, to raise self-esteem, to increase community bonds, and to create a better society” and in doing so cite Kelly [8], suggesting that technology sorts solutions for problems, rises our adaptability, and functions as a second skin between the world and ourselves.

The view that technology can increase adaptability suggests that technology is a tool to be used for some purpose. Avnet [9] argues that Creative Technologists can "...sketch with technology". As an emerging field, Creative Technologies covers different meanings including: the creative use of technology, the use of technology to enhance creativity, and also the creative inception of new technologies. Across all of these meanings, adaptability is a pre-requisite for Creative Technologists to constantly adapt to technological and social change.

3.2. B is for... Bricolage

Bricolage is a process of construction or creation from a diverse range of available things. Whilst the usage of the term is grounded in the crafts movement, it has been used as an effective strategy to deal with complexity [10]. Bricolage is often associated with resourcefulness and improvisation [11, 12] both of which can be considered as central to the practice of Creative Technologies.

The notion of "available things" is core to the idea of effectual thinking of entrepreneurial activity. Similarly, the ability to find and use such available things across traditional disciplinary boundaries also aligns with the undisciplined nature of the field. With this in mind, bricolage as an approach is synonymous with Creative Technologies.

This becomes clearer when considering the notion of an *assemblage*. Lanzara and Patriota [13] are discussing organisational knowledge when they state:

"...could be better pictured as an 'assemblage' subject to continuous transformations and reconfigurations. It is an assemblage precisely because it is the outcome of controversy and bricolage, resilient as a whole but subject to local disputes, experiments andreassembling."

However, this also describes both Creative Technologies outcomes as well as the field itself. The objects, systems and knowledge are constructs that can be challenged and changed as new thoughts, technologies and approaches arise. The process of continuous creation is characterized by ongoing transformations and reconfigurations.

The notion of an assemblage is defined [14] as "the continuous movement of parts in a restless flux in which the separate identities of the parts give way to a mutual coming and going, uniting and separating". Lanzara and Patriota [13] further describe an assemblage:

"An assemblage is neither a unity nor a totality, but a multiplicity, a collection of heterogeneous materials that are mutually but loosely interrelated. In other words, the notion stresses the importance of relations over the elementary parts, i.e. what goes on 'between' the part. In this regard, what makes knowledge distinctive is not the discrete collection of commodities, but the nature of the assemblage and, we should add, the making of the assemblage in

time. An assemblage is an evolving artifact and it is unique because it springs out of a unique history."

Creative Technologies is both an assemblage and the production of assemblages through a process of bricolage.

3.3. C is for... Collaborative

Continuing on the theme of an assemblage, because of its inter- and transdisciplinary nature, Creative Technologies often involves project teams that draw expertise from different disciplines. Indeed, such teams are often characterised by the nature of the project rather than through organisational structures. Such teams have been described by Gibbons et al. [15] in the context of new knowledge production as:

"Mode 2 research groups are less firmly institutionalised; people come together in temporary work teams and networks, which dissolve when a problem is solved or redefined. Members may then reassemble in different groups involving different people, often in different loci, around different problems. The experiences gathered in this process create a competence which becomes highly valued and which is transferred to new contexts. Though problems may be transient and groups short lived, the organisation and communication pattern persist as a matrix from which further groups and networks, dedicated to different problems, will be formed."

Such teams are inherently collaborative, a transient assemblage of people working towards a common goal. Whilst Creative Technologists may specialize, they need to not fall into a silo of thought and practice. Collaboration with others is key to understanding and addressing complex problems and the key to successful collaboration is a shared understanding and a sense of safety to take risks and learn from each other.

Language has been identified as one of the major challenges in crossing disciplinary boundaries [16], along with the observation that interdisciplinary fluency comes almost automatically if the boundaries between disciplines are not treated as barriers but instead as gateways leading to new things to explore [16]. Creative Technologies engenders curiosity and the confidence to open those gateways to see what lies beyond. Creative Technologies not only an osmotic and multilingual field, where words, techniques and knowledge are absorbed allowing wide ranging collaboration across and between disciplines, but bears all the hallmarks of being transliterate [17] in terms of both media and technological platforms

3.4. D is for... Disruptive

Creative Technologies draws from multiple disciplinary heritages but should not uncritically inherit their conventions. Creative Technologies have the potential to disrupt

conventions and to introduce new modes of thinking and practice into the mainstream. In a way, this disruption is a form of “gently trespassing” [16] in to other disciplines with a view to learn and engage, however done in such a way that that the act of trespass does not leave the traditional discipline untouched.

Given the nature of the Creative Technologies, with an emphasis on bricolage and hacking, there also exists the potential to create true disruptive innovation, which is defined by Schmidt and Druel [18] as products or services that first encroaches on the low end of the existing market and then diffuses upward. In this way, Creative Technologists not only creates disciplinary disruption but also economic, social and technological disruption through a process of creation.

3.5. E is for... Entrepreneurial

In this context, entrepreneurial is used to predominately imply the use of effectual thinking in addition to causal thinking. Rather than specify a mode of inquiry based around a goal to be achieved, Creative Technologists instead ask “What can I achieve?”. Effectual thinking, or effectuation, is described as analogous to a chef thinking of all of the meals they could create with a set of ingredients, as opposed to asking what ingredients are needed for a particular meal [19]. Entrepreneurial thinking also encompasses abductive logic, which is characterised as the logic of creativity or “what if?” and complements deductive reasoning from first principles, and inductive generalisations from observation.

In particular, Creative Technologies involves the application of effectuation, evaluation, and exploitation in the creative process [20] covering different modes of creative, cultural, social and institutional entrepreneurship. Creative Technologists have the potential to help build ecosystems that foster multiple modes of entrepreneurship in much the same way that they can bridge multiple disciplines.

3.6. F is for... Futurists

Creative Technologists are not futurists in the traditional sense used to describe attempts to predict the future. However, Creative Technologists do share similar foundations to futurists in terms of their interdisciplinary nature and grounding in systems thinking.

Futurists tend to predict the future in terms of the possible, probable, and preferable futures. These same possible futures exist in the world of Creative Technologies but not as predictions but as imagined futures. Creative Technologists are not attempting to predict the future but are instead trying to create it. They therefore fall in to a more general category of futurist that engage with the future because they “want to improve and innovate because they care and are obliged to contribute to the development and well-being of mankind” [21].

The ability to think speculatively in combination with technical competency has been identified as a requirement for the ability to be creative in the use of technology. Lukens and DiSalvo [22] state:

“Speculative design and technological fluency come together in an ability to be creative with technology—one that demonstrates the value of inquiry and experimentation. We consider creative inquiry as part of a broader ability to experiment or be creative with technology.”

This also reinforces the ideas that Creative Technologists need to be curious and understand the nature of inquiry in order to be effective at shaping new, possible futures.

3.7. G is for... Generation D

Generation D is the digital generation, also known as digital natives [23]. Arguably, this generation cannot imagine a world without the internet, computers and mobile devices. They skitter, haul, mod, and hack in a desire to shape the world. Digital natives are born in to environments that encourage multi-tasking [24] with the ability to use devices to increase their personal productivity, switch between modes of multi-tasking when appropriate and more focused efforts at other times.

When Zagalo and Branco [1] discuss Creative Technologies as a means to sustain self-realization, to raise self-esteem, and to increase community bonds, this is a natural trajectory for digital natives. Such use of technology drives new directions for technology, and as such digital natives are both the consumer and developers of Creative Technologies.

3.8. H is for... Humans

It has been argued that technology is a human construct, that is highly dependent on imagination, creativity, risk-taking and rewards [25]. Whilst technology (in its broadest sense) undeniably creates solutions to many individual and societal issues, it potentially causes as many problems as it solves. Whether Creative Technologies is the creative use of technology, the creative development of new technology or something entirely different; it is important to not lose sight of the human agency in those acts. This extends beyond human-centric thinking and incorporates concepts of values, morals and ethics to determine the direction for development.

In addition to this, the role of humans in the development of technology is changing. The goal of just making technology and systems easy to use is giving way to the goal of making technology and systems that are easy to develop and extend by end users [26]. This personalisation of technology is central to the Creative Technologies.

3.9. I is for... Interstitial

Creative Technologies is not a discipline in a conventional sense. It is a meta-discipline that exists between the spaces of traditional disciplines and is such best considered as being interstitial. In relation to the disciplines, this characteristic suggests that perhaps the Creative Technologies is

“antidisciplinary”, a phrase that does not oppose to traditional disciplines but implies “someone or something that doesn't fit within traditional academic discipline - a field of study with its own particular words, frameworks, and methods” [27]. It is a glue that binds things together, a vehicle that promotes problem solving across disciplines.

Antidisciplinarity is a particular mode of interdisciplinarity, of which there are many. All interdisciplinary work involves “crossing boundaries, making connections, moving and relocating ideas and generally involves integrating content from two or more disciplines and creating something new” [28]. However, particular challenges exist as a result of the obvious tension between an antidisciplinary or post-disciplinary stance and the modes of knowledge creation adopted by the more traditional disciplines.

3.10. J is for... Judgement

Judgement, or more specifically good judgement, is the ability to make considered decisions or come to sensible conclusions. Creative Technologists have the ability to make judgement, but also avoid the instant judgement that is the enemy of creativity [29]. Creative Technologists have the ability to play with so-called “bad ideas” in such a way to understand and reframe a problem to find innovative solutions and new ideas [30].

The creative process is generally considered as being an initial process of divergent thinking followed by later stages that are more closed, analytical and to a larger extent characterised by convergent thinking and formalised analysis [31]. Creative Technologists have the ability for generation of novelty (via divergent thinking) and evaluation of the novelty (via convergent thinking) [32] and apply their knowledge in both modes. However, they are not constrained by rigid processes and use their judgement to explore multiple options, to narrow down when appropriate but not be afraid of back-tracking and finding alternatives when necessary.

In this context, judgement is really a specific case of the more general concept of criticality. Creative Technologists should possess both creative and critical thinking [33] ability in order to shape the world around them.

3.11. K is for... Knowing

Whilst Creative Technologies incorporates the idea of making, it doesn't reject the concept of knowing. In relation to Aristotle's division of disciplines according to the concepts of *theoria*, *praxis* and *poiesis*, and the corresponding forms of knowledge *episteme*, *phronesis* and *techne* [34]. Aristotle explains these types of knowledge “theoretical knowledge whose purpose is reality”, “practical knowledge whose purpose is action” and “poietic knowledge whose purpose is creation”. Creative Technologies involves all three forms of knowledge. These terms roughly correspond to “thinking”, “doing” and “making”. The binding together of these elements is achieved through *philotechne*, the “love of craft”.

Philotechnicians construct the theory/praxis/poiesis relation on the basis of poiesis: the aim is to produce something beautiful from something already existing [35]. This reinforces the characteristics of bricolage and effectual thinking. Creative Technologists assemble something new from existing ideas, technologies or methods.

3.12. L is for... Learning

Learning is generally considered the acquisition of knowledge or skills through study, experience, or being taught. Whilst all modes of learning are relevant, Creative Technologies embraces the concepts of experiential and self-directed learning as the primary mode. Experiential learning is the process whereby knowledge is created through the transformation of experience [36]. There is an overlapping relationship between the concepts of learning, knowing and making that exists and made coherent through a process of reflection. This is not to suggest that reflection is an entirely cognitive process, indeed reflection can be considered as an embodied process [37] that can be applied to the act of making.

Irrespective of how people learn, it has been noted that curiosity is a major driver for effective learning. Indeed, research shows unequivocally that when people are curious about something, they learn more, and better. [38]. Curiosity naturally leads to discovery [39], and Creative Technologies is a mechanism that facilitates discovery and self-directed learning. Creative Technologists should be curious about the world in which they live, and this curiosity should drive their sense of discovery and underpin their lifelong learning.

3.13. M is for... Making

Whilst the creation of new knowledge through a combination of making, thinking and doing has already been discussed, the role of making in Creative Technologies is deeper. It is not just about making, but a culture of making. The idea of the “maker culture” is not new. Yet there is a growing interest in creativity and making as a result of consumers increasingly becoming co-creators [40]. The ideas of shared spaces, tinkering and prototyping [41] all underpin the hacking methods utilised by Creative Technologists.

To defy existing conventions and develop new modes of thinking, it is necessary for Creative Technologists to not be obsessed with perfection and be prepared to take and use ideas or technologies into new contexts. Whilst bricolage is used to describe the recombination of different ideas or technologies as demonstration of feasibility for new solutions, hacking is about timescale. Hacking is the process of creating solutions to problems that may not be perfect. It is a form of making that is not focused on final production, but instead making as means of discovering, learning and integrating.

3.14. N is for... Novelty

Creative Technologies is an assemblage of ideas, methods, techniques, and technologies, so novelty is maintained through a process of constant reinvention. New ideas emerge and are absorbed into the mix which in turn stimulates further new ideas. This presents both challenges and opportunities for the field. On one hand, this constant change produces its own instance of “disciplinary churning” [42] that results in uncertain grounding of ideas. However, this uncertainty also becomes a lever for the curious to identify new directions for inquiry.

There is a clear relationship between novelty-seeking behaviour and creativity [43, 44]. Similarly, It has been argued that novelty and creativity are inherent aspects of the phenomena of comprehending and learning [45]. Whilst Creative Technologies is a producer of novelty, the role of the individual in that process cannot be overlooked. A key feature of finding something new is the ability to think in ways that differ from established lines of thought [46]. Creative Technologists have this potential through the ability to disrupt discipline norms and as such exhibit novelty seeking behaviour.

3.15. O is for... Openness

As well as being between disciplines, Creative Technologies has porous boundaries and knowledge, tools and techniques constantly flow across the boundaries that distinguish Creative Technologies from the disciplines themselves. History has occasionally been witness to a creative osmosis between the everyday and more specialised knowledge [47] and Creative Technologies continues this trend. Through the maker culture, collaboration and the focus on self-realisation [1] there is the potential to inform and expand everyday knowledge by engaging communities in a process of co-creation.

However, openness does not just relate to the field itself and its relationship with the disciplines. Creative Technologists are inherently open themselves in every sense. They are open to idea, produce open solutions to problems and open themselves to share ideas and approaches with the wider community.

3.16. P is for... Purpose

Purpose is defined as the reason for which something is done or created or for which something exists. Creative Technologists act with purpose and create with purpose in mind. The nature of that purpose can be varied, and purpose is therefore an umbrella concept that embraces ideas such as problem (solving), proposition and interrogation. Just as Press argues that “a designed artifact is a researched proposition for changing reality” [48], the purpose of a Creative Technologies project is to reach an outcome that influences the environment in which the outcome exists. This can be the solution of a tangible project, the creation of an

idea that stimulates further debate and discussion or a form of action that leads to achieving a goal.

The scope of such purpose is open to the imagination, but the general guidelines suggested by Zagalo and Branco [1], namely to sustain self-realization, to raise self-esteem, to increase community bonds, and to create a better society are a general framework that apply. However, society would be better replaced with world, as there is now reason why Creative Technologies cannot have an impact on issues wider than society, such as the environment.

3.17. Q is for... Quixotic

Creative Technologies has the potential to embrace romantic ideals and ignore practicality in the quest for new knowledge. Whilst not necessarily good judgement, embracing impracticality is an informed judgement rather than an accidental practice.

Absurd or impractical ideas, are important in all creative group processes for generating significant alternatives [49]. An idea that may seem impractical may contain a germ of a great solution [50] and the Creative Technologies encourages the wilful and purposeful exploration of the absurd and impractical to help in the reframing of problems or issues to be explored.

Creative Technologies is by its nature playful, and can be both spontaneous and undirected. Play, creativity and community are linked through the common ground of divergent thinking, a process that generates a variety of ideas and associations to a given problem. There is a variety of research evidence that suggests that play facilitates both divergent thinking and creativity [51], both of which are considered to be of considerable importance in the development of Creative Technologists. The quixotic and the playful come together in the creating of imagined futures in order to understand it better [52].

Creative Technologists embrace the unexpected and direct their inquiry into directions others may choose to ignore. In this regard, playfulness is associated with curiosity, creativity and exploration.

3.18. R is for... Resourceful

Creative Technologists are resourceful, they are creative and imaginative and can envisage solutions with what is to hand, even if that is being used out of context. Creative Technologies has been noted as the means to “transpose the notion of practice directly to community members to focus upon situations outside or at the periphery of the arts where user-led content creation and resourceful practices of ‘making do’ become creative tactics” [53]. Resourcefulness is a characteristic that supports the entrepreneurial nature of the Creative Technologies and drives the ability to apply effectual thinking.

It has also been noted that technology is not always used for the purpose it was designed. Individuals appropriate and use technology in their own innovative, creative and sometimes unexpected ways. This is a form of

resourcefulness that can include the customisation of consumer products, collective cultural or artistic output emerging from experimenting with new technologies [54]. In this context, the Creative Technologies promote such resourcefulness through parallel processes of imagineering [55] and bricolage [56, 57].

3.19. S is for... Scholarly

With a clear methodological bias towards making, hacking and bricolage it would be easy for the Creative Technologies to lose sight of its position in the context of scholarly activity and the production of knowledge and become lost in the activity of crafting or making. There is a clear tension between scholarly credibility and other concepts in this article, and this is included specifically to bring that tension to the fore and not lost. Other fields of study have struggled with credibility in terms of scholarly activity, for example it has been argued that digital visualisation approaches produce outputs that are scholarly activity [58] and here it is important to distinguish between the outcome and the practice.

Scholarly activity is about the discovery, exchange, interpretation, and presentation of knowledge. As such it is inquiry-driven, and the outcome of that inquiry can potentially take many forms. The challenge for Creative Technologies is to define what scholarship in this field is, the criteria of quality, and to promote the acceptance of the outcomes achieved.

3.20. T is for... Tangible

Whilst tangible interaction [59-61] is currently a focus for the Creative Technologies, this is used to mean more than the physical. In this context, tangible is used to describe a form of “conceptual tangibility” that is a rejection of ambiguity. This tangibility is what separates Creative Technologies from art and art practice, that often seek to embrace ambiguity [62]. Ambiguity can result in the loss of connection to both the concept and context of the work, which results in the outcomes becoming unclear and confusing which then detracts from the credibility of the outcome.

The focus on conceptual tangibility drives the Creative Technologies towards the solution of problems in a way that adds value to society. However, in this context, value does not necessarily imply the most efficient or most obvious solution. Whilst a concrete concept is essential, this does not preclude creative, tangential solutions that embrace the unexpected. In this regard, a distinct risk exists in this field to fall prey to “solutionism”, especially the uncritical belief that all problems can be solved by technocratic means.

3.21. U is for... Undisciplined

Whilst the word “undisciplined” may suggest a lack of organisation or rigour, it is used in a different context. Bremner & Rogers [3] describe undisciplinarity as a state of practice that has shifted from “discipline-based” to “issue- or

project-based” and therefore connects distinct disciplinary practices. They go on to state that:

“Undisciplinarity is as much a way of doing work as it is a departure from ways of doing work. It is an approach to creating and circulating culture that can go its own way without worrying about what histories-of-disciplines say is ‘proper’ work.”

Undisciplined working is therefore used to describe a form of methodological and technological bricolage. Undisciplinarity has been associated with a number of fields that share characteristics with Creative Technologies, namely a set of activities that are not a discipline. Such fields include urban planning [63], fan studies [64] and marine conversation [65] to name but a few. Nearly all fields that are described as an “undisciplined discipline” typically exhibit five characteristics of issue-driven interdisciplinarity: being problem-based, integration, interactivity and emergence, reflexivity, and strong forms of collaboration and partnership [66]. These characteristics are clearly apparent in the Creative Technologies.

3.22. V is for... Value

Creative Technologies must have both intrinsic (self) value as well as add value. The latter may be interpreted in the broadest sense – artistic, economic, social or technical to suggest just a few possible interpretations. This value arises from the conceptual tangibility of the work undertaken, each project is undertaken for a purpose or reason that can be grounded in a given cause. Even the more abstract projects should be conceptualised through a form of inquiry, where a clear question or notion drives the project.

The sense of intrinsic value arises naturally from undertaken projects that add value. Creative Technologies could easily be criticised for a lack of methodological rigour when viewed from the perspective of one or more of the traditional disciplines. But the ultimate response to such criticism can arise from the value added through the projects undertaken.

This value can best be considered through the concept of impact. Projects or research contributions that exist purely as curiosities simply lack the ability to make a positive impact on our culture and society. The professional ability to assess the impact of interventions cannot be over-emphasised in this field.

3.23. W is for... Wicked

As our world has grown increasingly complex, so have the problems and issues that we face. In recent years, the term “wicked problems” [67] has increasingly been used to characterise problems that are difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognise. The literature related to such problems has identified a number of themes, namely that because of their ill-defined nature, there is

a need to think and work in innovative ways that require flexible and creative thinking [68] and that such problems require thought and action across multiple disciplines [69].

As a field that draws upon multiple disciplines but is not constrained by any, Creative Technologies offers the potential to produce solutions to such complex problems. In order to make such solutions effective, Creative Technologists need to be experts in problem framing [48] as much as problem solving. They need to be able to act collaboratively in teams, to learn and share that learning across the teams and drive the search for creative solutions.

Moreover, the term wicked in this context also seeks to capture the eccentric and unconventional nature of solutions and interventions in Creative Technologies. Just as problems that are ill-structured are distinguished from "tame" or routine problems for which one correct end goal exists, creative solutions can often appear at first as wacky or non-obvious.

3.24. X is for... Xenogenesis

Xenogenesis is a biological process whereby a generation of offspring is completely and permanently different from the parents. Creative Technologies is an "undisciplined child" that draws upon the disciplinary heritage of its parents, of which there are many [4], but is uniquely different from them. It is not a discipline, so is not bound by the same conventions and constraints as the disciplines themselves. Creative Technologies encourages new ways of thinking, new ways of knowing and through its osmotic boundaries it brings together individuals from different disciplines and binds them together in a common purpose.

However, the problems explored by Creative Technologies change over time and therefore any drawing together of thoughts or approaches for a given problem quickly becomes redundant as new problems arise.

3.25. Y is for... You

To say "Creative Technologies needs You!" may be hyperbole, there is more than a grain of truth in this statement. Creative Technologies is an emerging and growing field, uncertain of its own heritage and direction. As it develops and grows, the actions of individuals will shape the field and give it credibility in a wider arena.

In addition, the identity and agency of the individuals and teams working in this area are fundamental, as they invariably embed their personal and cultural values and worldviews into their work. Ethically, this is a core reason why diversity is imperative in Creative Technologies to guarantee more inclusive and humane technologies. Having said this, the nature of authorship in Creative Technologies is malleable and ranges from more ego-centric approaches usually found in artistic fields to more service-oriented approaches characteristic of design and engineering. Healthy conversations and debates are recommended on the model and role of authorship in every project.

3.26. Z is for... Zetetic

Whether Creative Technologies is quixotic and undisciplined or scholarly and purposeful, it is founded in the concept of inquiry, whether it be playful or serious. The drive for new technologies, new solutions and new knowledge is driven through a process of inquiry that satisfies curiosity.

Creative Technologies bears many resemblances to the field of zetetics that had a short period of popularity in the 1960s and early 1970s [70, 71]. Zetetics (from Greek *zētētikos*, from *zēteō* to seek) was proposed by Joseph Tykociner as a scientific study of research and artistic activity, with the view of producing an all-encompassing knowledge system that promoted understanding and utilising the process which lead to discoveries, inventions and the solution of human problems. Part of the goal of zetetics was understanding "the origin, systematization, delineation and selection of research problems" and zetesis is further defined as "that activity which converts the unknown into the known and transforms our present state of knowledge into a more precise, a more expanded, and a more unified state."

Within this, it was argued that the advancement of knowledge is too often seen as the "unrelated" work of researchers in "different" areas of knowledge. Therefore Zetetics studies the "similarities" and "unity" of the goals of all creative effort. Arguably, zetetics was just ahead of its time as many of the points around disciplinary collaboration and the construction of new knowledge could be read as a manifesto for Creative Technologies.

4. Discussion

The terms and definitions in Section 3 were developed iteratively applying the method described in Section 2. This text became a corpus that allowed for relationships between concepts to be identified and examined in depth. An initial identification of these relationships was undertaken independently by the authors through a concept relationship matrix. This process involved the pairing of concepts to determine whether a relationship was identifiable between every pair. For example, the text associated with "Adaptable" was assessed in relation to "Bricolage", "Collaboration", and so on.

A mix of coincidences and discrepancies emerged from this process reflecting the different interpretations of the text. Inasmuch as Creative Technologies emerges from the confluence of multiple disciplinary traditions, the goal of the independent analyses by experts from different areas was not to maximise inter-rater agreement, but to identify where consensus naturally occurred and to provide a structure for dialogue. The value of this exercise is that it yields a visual means to identify the possible core characteristics of the Creative Technologies and their possible roles in orienting education and practice efforts. This is achieved by pinpointing strongly reinforced relationships, such as those highlighted in Figure 2.

Concepts are required or implied by the narrative in the corresponding row when a tick is present in the column

	Adaptable	Bricolage	Collaboration	Disruptive	Entrepreneurial	Futurists	Generation D	Humans	Interstitial	Judgement	Knowing	Learning	Making	Novelty	Openness	Purpose	Quixotic	Resourceful	Scholarly	Tangible	Undisciplined	Value	Wicked	Xenogenesis	You	Zetetic		
Adaptable	✗					✓									✓		✓											
Bricolage		✗				✓											✓											
Collaboration	✓		✗													✓	✓	✓							✓			
Disruptive		✓		✓											✓									✓	✓			
Entrepreneurial		✓		✗														✓	✓				✓					
Futurists						✓									✓	✓							✓	✓				
Generation D						✗	✓									✓												
Humans							✗		✗																			
Interstitial																			✓	✓								
Judgement									✗	✓						✓									✓			
Knowing	✓									✗						✓												
Learning																✓		✓										✓
Making	✓															✓	✗											
Novelty	✓		✓												✓		✗											✓
Openness									✓									✗										✓
Purpose									✓	✓						✓		✗					✓	✓	✓	✓	✓	
Quixotic										✓								✓	✗									
Resourceful	✓	✓																✓		✗								
Scholarly																	✓											
Tangible																		✓										
Undisciplined	✓	✓								✓							✓			✗								
Value											✓							✓										✓
Wicked	✓		✓	✓	✓											✓		✓					✓					
Xeogenesis	✓																✓											
You			✓																									✗
Zetetic			✓													✓	✓										✗	

Figure 2. Concept Relationship Matrix

The immediate observation from Figure 2 is that the relationships are non-symmetrical, which suggests a degree of directionality between the characteristics of the Creative Technologies. When these characteristics are paired, they may serve either as means or ends to make Creative Technologies possible. An example of this directionality is “Collaboration”, which is considered to require a certain amount of “Adaptability” to enable creative teamwork, but the converse is not necessarily true since a practitioner can also demonstrate high adaptability individually.

This directionality is further reinforced by identifying that the characteristics of the Creative Technologies with the most outgoing connections (the rows in the matrix) are not always the same as those with the greatest number of incoming connections (the columns in the matrix). To reiterate, the matrix in Figure 2 only captures the agreed upon relationships identified independently by the authors with very different disciplinary backgrounds, so the list of characteristics defined

in Section 3 can be used to elicit distinctive perceptions about the defining features of Creative Technologies, as well as to draw out coincidences across disciplinary and professional chasms.

We propose that this directionality can be valuable to orient dialogue and decisions across disciplinary and professional chasms about curriculum design, the definition of graduate profiles, and job descriptions. It is noteworthy that the column values in Figure 2 present a more skewed distribution than those in the rows. This is captured by measuring the number of relationships in the matrix resulting in a standard deviation twice as large in columns than rows. This suggests that the characteristics in Section 3 can be considered alternatively as instrumental means to develop the Creative Technologies, or as targets or outcomes that define it. In other words, terms with a high number of incoming connections can be used for tactical purposes such as the selection of pedagogical approaches, whilst terms with a high

number of outgoing connections can be used for strategic purposes such as in the definition of learning outcomes.

The two terms with the greatest number of incoming connections are “Learning” and “Purpose”, with more than triple the average. Learning, for example, is identified as a key contributor or support for a range of characteristics including collaboration, disruptiveness, making, as well as the seemingly mutually exclusive “Scholarly” and “Undisciplined”. This captures the centrality of learning beyond the individual, but as a general mode of ongoing discovery in a relatively young field. In a field where textbooks are of limited relevance, cultivating a capacity for life-long learning is important to bring about the contributions of the Creative Technologies.

Meanwhile, “Purpose” is considered as orienting or enabling adaptability, future-oriented action, resourcefulness, and value creation, amongst others. The high number of incoming connections here illustrates the open-endedness as well as the purposeful and applied nature of the Creative Technologies. The modal value for incoming connections (columns) is 1, whilst a modal value of 4 for outgoing connections (rows) reinforces the difference in variances and shows a more uniform distribution across characteristics that distinguish the outcomes of Creative Technologies. These include adaptability, bricolage, collaboration, disruptiveness, future-oriented action, knowing, novelty, undisciplined, and Zetetic. “Bricolage” is a term that scores high in both

incoming and outgoing connections. Whilst an exhaustive analysis of all relationships is beyond the scope of this paper, the analysis here shows the demonstrable value of the corpus and the matrix presented in this paper.

As an alternative means to visualise the corpus, the text of Section 3 has been used to create a word cloud shown in Figure 3 (using the generator wordclouds.com). The process involved collating the paragraph text from Section 3 removing all references to “creative technologies” and “creative technologists”. All text was converted to lower case, author names were removed as were all words with only one occurrence. The initial word cloud was generated with the option to remove common stop words, then a number of words were removed manually. Examples of these words include “may”, “can” and “whilst”, though this is not an exhaustive list. In the same process, words with the same root were collated together. Obvious examples would be “create” and “created”, though less obvious would be “thinking” and “thought”.

In the resulting word cloud, the size of each word is an indication of the frequency of use in the text and therefore provides an insight into the relative importance of particular ideas irrespective of the structure used to derive them. The content of the word cloud clearly contains some of the same concepts as identified in Figure 2, as well as words that support and underpin the ideas.



Figure 3. Creative Technologies Word Cloud

Given that the genesis of this paper was the emulation of an attempt to characterise Design [7] using a similar format, it is worth identifying key similarities and differences between both Creative Technologies and Design. An immediate difference is the maturity of the disciplines, with the former currently identifying some of the existential crises that the latter experienced in the last decades of the twentieth century. In that evolution, Cross referred to a “designerly” culture that differs from scientific and artistic traditions in knowledge, methods, and belief systems [72]. As a young field, Creative Technologies faces today a “paucity of language and concepts” similar to that of Design decades ago. The work presented here shows clear value to support scholars and practitioners of Creative Technologies to articulate that emerging identity. It is possible that such journey of self-discovery leads to the expert integration of knowledge and skills across the belief systems of disciplines. As Creative Technologies evolves, it will no doubt continue to bear a resemblance to Design, and potentially even collapse into Design itself. On the other hand, the authors believe that current societal circumstances will produce a discipline that embraces and uses design concepts in the same way that it uses other bodies of knowledge as a means to create using technology, to understand and support creativity through technology, and also to creatively conceive new technologies.

5. Conclusions

This paper has emulated the process used by authors in the design discipline to identify the characteristics of Creative Technologies and use this to articulate and support dialogues that refine our understanding of this field. Whilst the outcomes of this remain highly dependent on the perspectives and experiences of the authors, it still provides insight into how this field is emerging and becoming established.

As an approach, the development of this understanding offers the potential for educators and researchers to work together to identify what needs to be included in Creative Technologies programmes and how to ensure credibility in research. This can be achieved through multi-institutional and international collaboration, using the contents of this paper as a starting point to challenge, communicate, and achieve consensus. As mutual understanding emerges, it can be used to develop a strong international community in this field.

One of the primary hopes moving forward is that engagement with the wider Creative Technologies community will enable the relatively artificial alphabetic construct to be condensed in to a smaller number of key concepts or terms that embrace this broad starting point. This set of characteristics can be used to both refine existing Creative Technologies programmes and develop new ones to enable a global understanding of the domain. Examples of how this could be useful would be in using the terms to write programme graduate capabilities and course learning outcomes, and to expose young students to these terms as a way to introduce them to the defining characteristics and generative tensions of the field.

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