Pedagogy of uncertainty: Laying down a path in walking with STEAM

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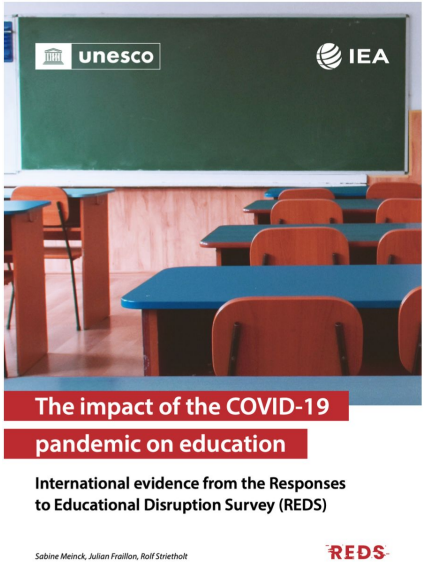
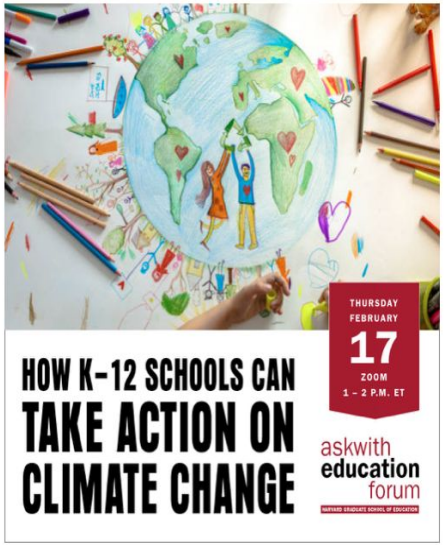
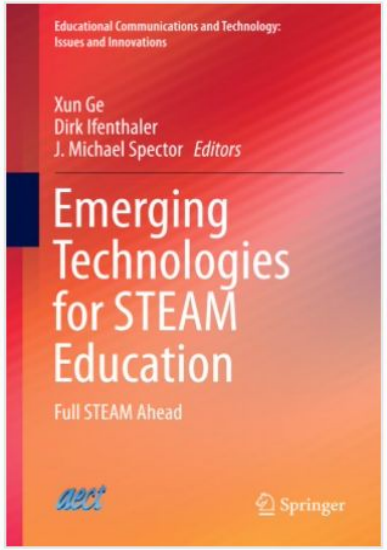
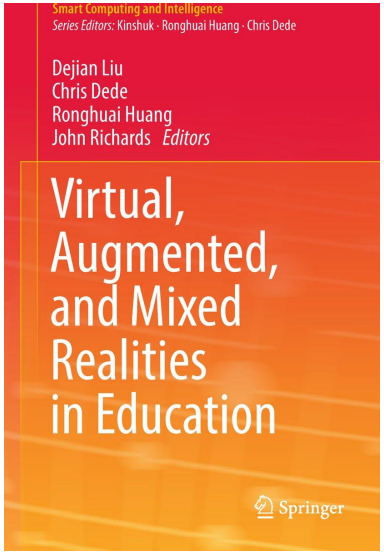
CONTEXT





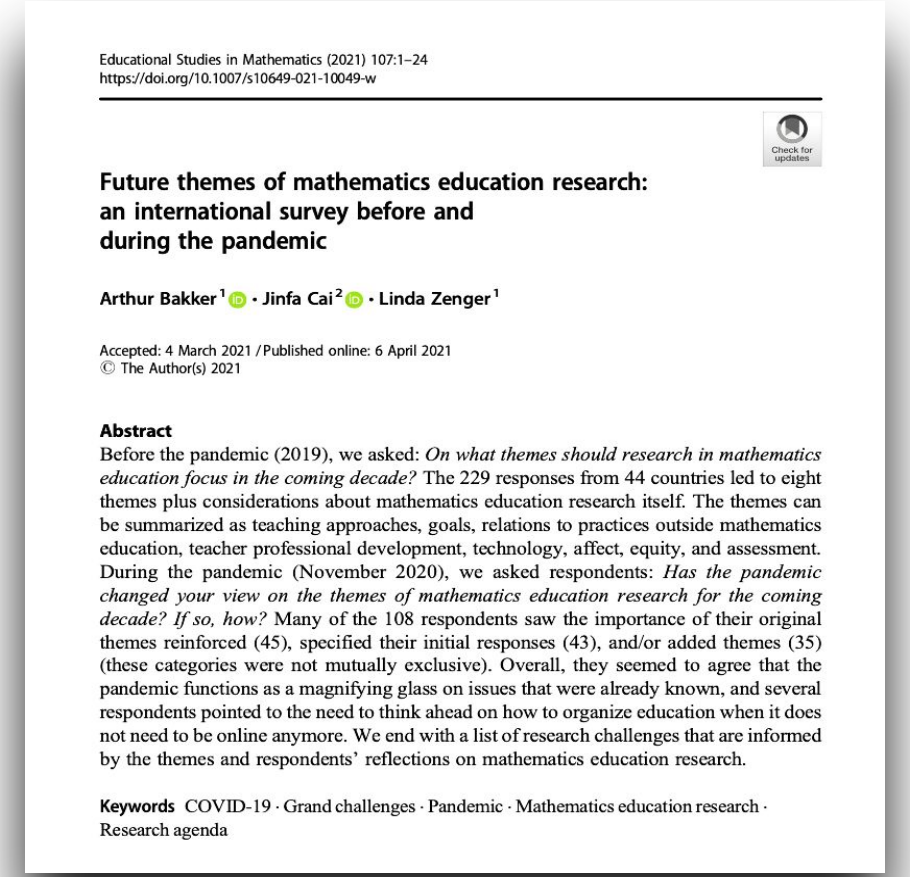




Educators around the world are facing the challenges and opportunities of 21st Century education, such as the COVID-19 pandemic, Climate Change, STEAM education and the rise of digital immersive technologies presenting a promising field for the development of new ways of maximising the learning experience (Bakker, Cai & Zenger, 2021).

All these ongoing and unpredictable changes lead to a new framework of **pedagogical action based on uncertainty**, since they are unfamiliar or unknown in the field of traditional education

Empirical evidence: Education and COVID-19 pandemic



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Check for updates

Future themes of mathematics education research: an international survey before and during the pandemic

Arthur Bakker[1] · Jinfa Cai[2] · Linda Zenger[1]

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Abstract
Before the pandemic (2019), we asked: *On what themes should research in mathematics education focus in the coming decade?* The 229 responses from 44 countries led to eight themes plus considerations about mathematics education research itself. The themes can be summarized as teaching approaches, goals, relations to practices outside mathematics education, teacher professional development, technology, affect, equity, and assessment. During the pandemic (November 2020), we asked respondents: *Has the pandemic changed your view on the themes of mathematics education research for the coming decade? If so, how?* Many of the 108 respondents saw the importance of their original themes reinforced (45), specified their initial responses (43), and/or added themes (35) (these categories were not mutually exclusive). Overall, they seemed to agree that the pandemic functions as a magnifying glass on issues that were already known, and several respondents pointed to the need to think ahead on how to organize education when it does not need to be online anymore. We end with a list of research challenges that are informed by the themes and respondents' reflections on mathematics education research.

Keywords COVID-19 · Grand challenges · Pandemic · Mathematics education research · Research agenda

On what themes should research in mathematics education focus in the coming decade? The 229 responses from 44 countries led to eight themes plus considerations about mathematics education research itself. The themes can be summarized as **teaching approaches**, goals, **relations to practices outside mathematics education**, teacher professional development, **technology**, affect, equity, and assessment.

Empirical evidence: Wicked Problems

HUNGER

INCOME DISPARITY

GLOBAL WARMING

ECOLOGICAL DECAY

FINANCIAL CRISES

TERRORISM

CLIMATE CHANGE

SUSTAINABLE DEVELOPMENT

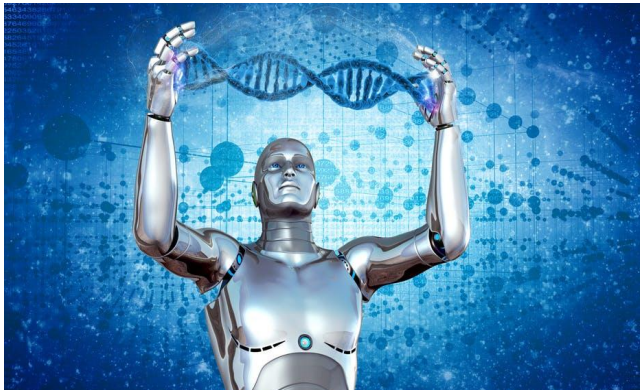
EDUCATION DESIGN

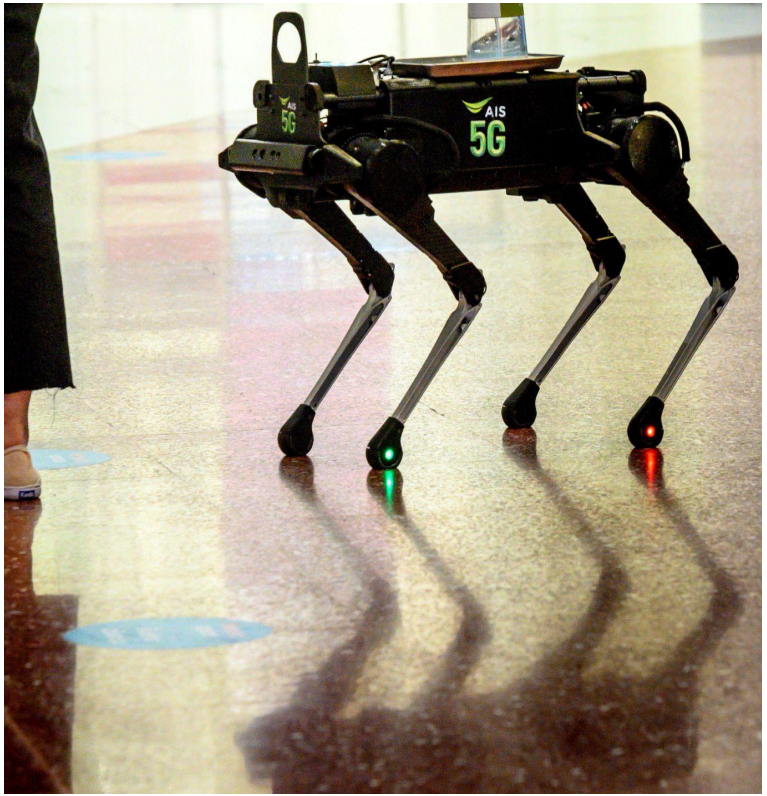
HEALTH CARE

POVERTY

GENDER EQUALITY

Empirical evidence: New learning Technologies, IoT, AI, Big Data...





How to deal with an unknown world?

From the evidence presented, we consider relevant to investigate in the next decade teaching approaches, the **shifting role of the teacher,** relationships with practices outside the classroom and new **technologies** from **STEAM applied to real and global problems that threaten peace and life on the planet**.

The integration of science, technology, engineering, arts and mathematics (STEAM) offers an approach to educational design based on curricular integration and learning by doing with analog and virtual technologies (Quigley et al., 2020). STEAM is a systemic, dynamic and embodied approach that goes against a static pedagogy of certainty.

We allude to a pedagogy of certainty or traditional education in those educational practices in which didactic designs and teaching methodologies are based on decontextualized and a-historical problems, subtracted from the agency of the body and experience, in which asymmetry is also relieved. of the educator over the learner and the monolithic hegemony of teaching over an integrated one.

Empirical evidence: STEAM Education

STEAM Enacted: A Case Study of a Middle School Teacher Implementing STEAM Instructional Practices

ARTICLE

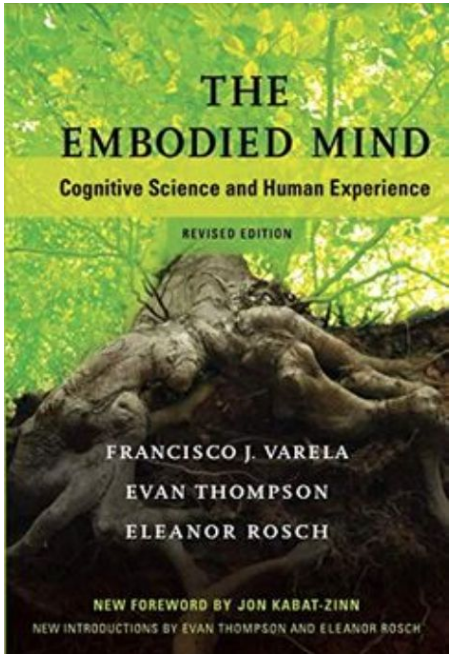
Danielle Herro, Cassie Quigley, Clemson University, United States

JCMST Volume 35, Number 4, October 2016 ISSN 0731-9258 Publisher: Association for the Advancement of Computing in Education (AACE), Waynesville, NC USA

Project-based learning, technology integration, and transdisciplinary teaching are the lens from which the teacher's lesson and reflections are deconstructed. **Challenges in STEAM teaching** are discussed including the **shifting role of the teacher**, **determining student collaboration, and time**. This is part of a larger study examining the STEAM teaching practices of 43 middle school science and math teachers.

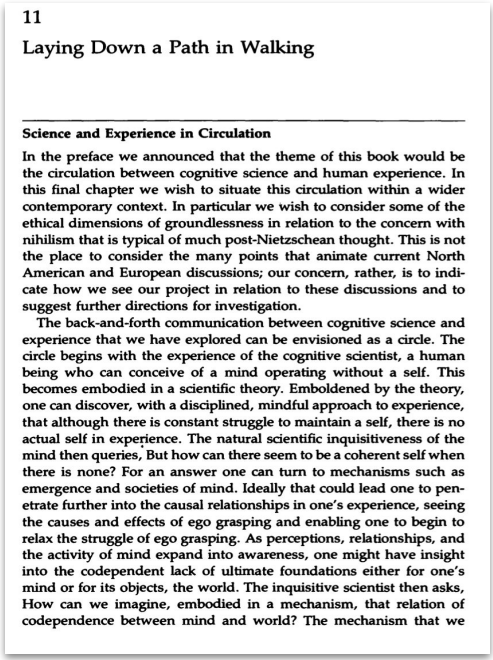
The **pedagogy of uncertainty** approach that we suggest here is based on the potential of **STEAM educational environment design** that focuses on **providing signs or patterns of an emerging world**, unlike traditional teaching methods in which **the path to which students should arrive is already laid down in advance**.

Pedagogy of uncertainty: Laying down a path in walking



STEAM + Enactivism

From a STEAM educational design approach, **the teacher and her/his students *lay down a path in walking together*,** a motto used by the enactive approach to cognition that considers "**cognition as embodied action that is always oriented towards something absent:** on the one hand, there is always a next step for the system in its perceptually guided action; for the rest, the acts of the system are always directed towards situations that are not yet in act" **(Varela, Thompson & Rosch, 1991, p.238)**



11

Laying Down a Path in Walking

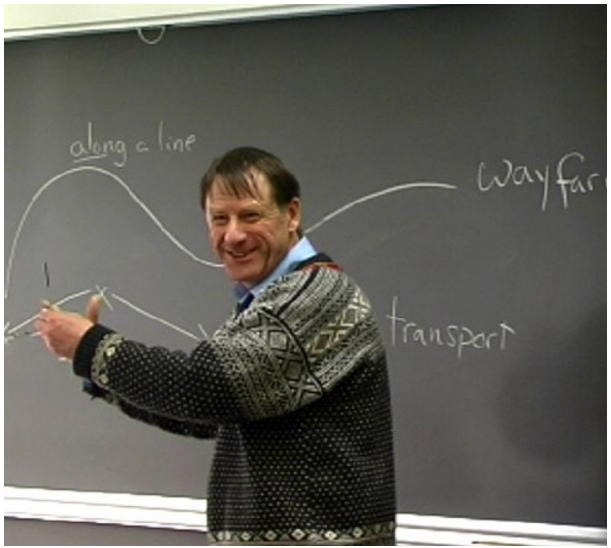
Science and Experience in Circulation

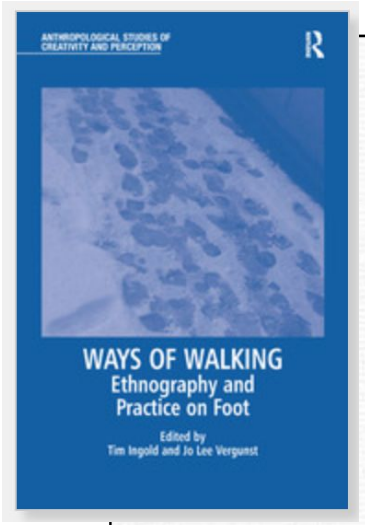
In the preface we announced that the theme of this book would be the circulation between cognitive science and human experience. In this final chapter we wish to situate this circulation within a wider contemporary context. In particular we wish to consider some of the ethical dimensions of groundlessness in relation to the concern with nihilism that is typical of much post-Nietzschean thought. This is not the place to consider the many points that animate current North American and European discussions; our concern, rather, is to indicate how we see our project in relation to these discussions and to suggest further directions for investigation.

The back-and-forth communication between cognitive science and experience that we have explored can be envisioned as a circle. The circle begins with the experience of the cognitive scientist, a human being who can conceive of a mind operating without a self. This becomes embodied in a scientific theory. Emboldened by the theory, one can discover, with a disciplined, mindful approach to experience, that although there is constant struggle to maintain a self, there is no actual self in experience. The natural scientific inquisitiveness of the mind then queries, But how can there seem to be a coherent self when there is none? For an answer one can turn to mechanisms such as emergence and societies of mind. Ideally that could lead one to penetrate further into the causal relationships in one's experience, seeing the causes and effects of ego grasping and enabling one to begin to relax the struggle of ego grasping. As perceptions, relationships, and the activity of mind expand into awareness, one might have insight into the codependent lack of ultimate foundations either for one's mind or for its objects, the world. The inquisitive scientist then asks, How can we imagine, embodied in a mechanism, that relation of codependence between mind and world? The mechanism that we

"And that he is finally a person, but a knot of all the lines, of all the paths of growth and movement, that come together and open up around him"

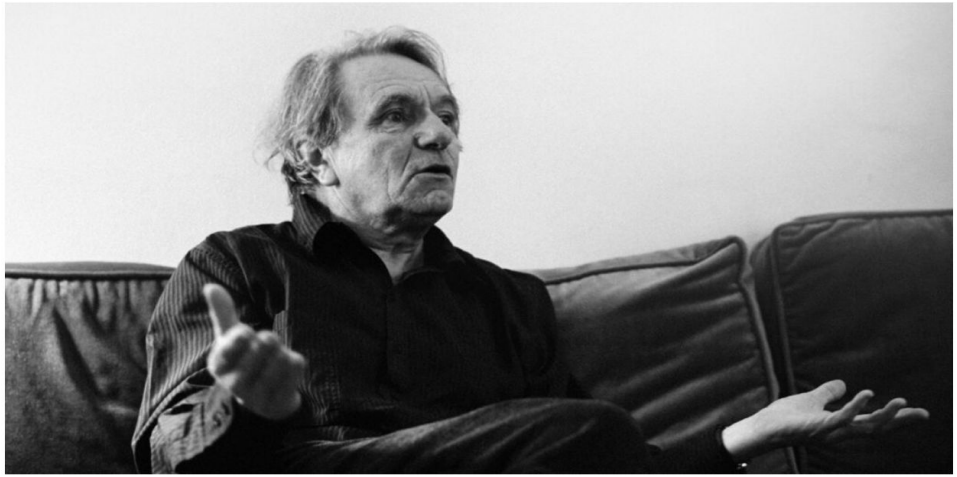
(Ingold, 2007)

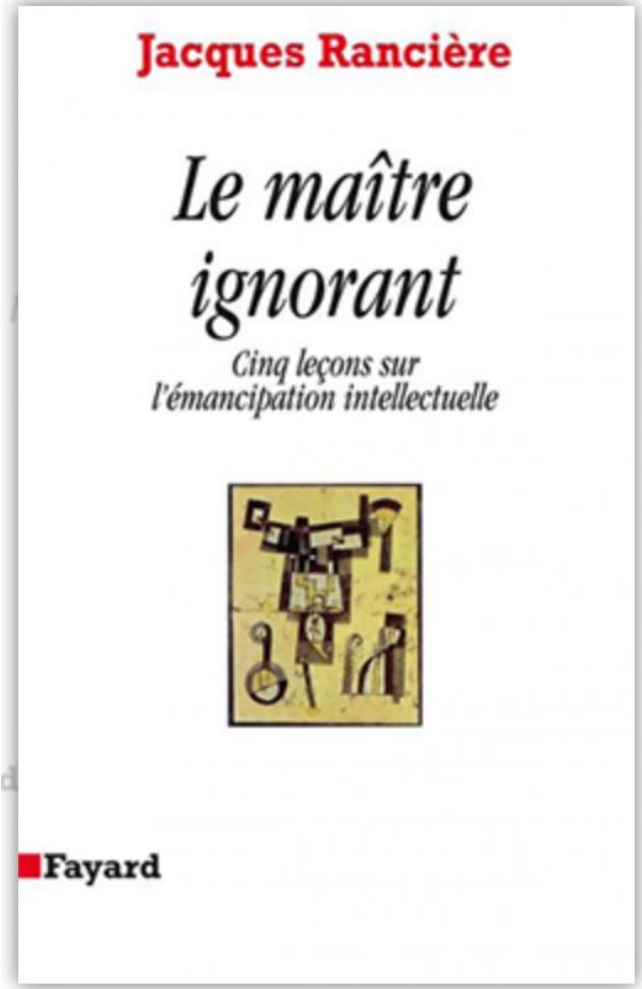




"The act of teaching could take place according to four differently combined determinations: by an emancipating master or by a stunning master; by a wise master or by an ignorant master. The emancipating master frees the learner and the stunner helps keep him on his path. While the wise master is due to his science, the ignorant master what he ignores (p.12)"

(*Rancière* , 1987)





Flexible learning focuses on giving students choice in the pace, place and mode of their learning, and all three aspects can be assisted and promoted through appropriate pedagogical practice, practice that can itself be supported and enhanced through e-learning (Gordon, 2014).

Pedagogy of uncertainty: A Proposal

In contrast to a static pedagogy based on didactic sequences that are already set in advance and available for both students and teachers to follow, we propose a **Pedagogy of uncertainty** where teachers and learners lay down a path in walking, exploring and learning how to deal with an uncertain world, through non-linear pedagogical journeys such as STEAM, and emerging learning inspired in enactivism

Pedagogy of uncertainty: A Proposal

For this we embrace the **embodied design** educational design paradigm (Abrahamson, 2015), and the **enactive-ecological continuum** approach in STEAM design (Videla, Aguayo & Veloz, 2021)

Foundations of a pedagogy of uncertainty: Embodied design

Abrahamson, D., Dutton, E., & Bakker, A. (in press). Towards an enactivist mathematics pedagogy.
In S. A. Stolz (Ed.), *The body, embodiment, and education: An interdisciplinary approach*. Routledge.
[NB: due for publication around mid-2021].

Towards an Enactivist Mathematics Pedagogy

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Abstract
Enactivism theorizes thinking as situated doing. Mathematical thinking, specifically, is handling imaginary objects, and learning is coming to perceive objects and reflecting on this activity. Putting theory to practice, Abrahamson's embodied-design collaborative interdisciplinary research program has been designing and evaluating interactive tablet applications centered on motor-control tasks whose perceptual solutions then form the basis for understanding

We explore the notion of **pedagogy of uncertainty in the light of enactivism**, based on theoretical and empirical evidence about how teachers and students deal with an uncertain world by actively participating in integrated educational environments based on learning by doing approaches (Abrahamson, Dutton & Bakker, 2021).

Foundations of a pedagogy of uncertainty: Embodied design

In embodied design activities, **learners make sense of situations** by first drawing on their tacit perceptuomotor capacity, then encountering the disciplinary analysis on the same situation, and finally reconciling these competing views as complementary. **First, learners encounter interaction problems that require them to figure out how to enact** a particular new movement form. Then, they use formal STEM instruments that suggest a complementary yet non-contradictory (Ba & Abrahamson, 2021),

Ba, H., Abrahamson, D. (2021) Educational Designer, 4(14)

ED EDUCATIONAL DESIGNER

JOURNAL OF THE INTERNATIONAL SOCIETY FOR DESIGN AND DEVELOPMENT IN EDUCATION

Taking Design to Task: A Dialogue on Task-Initiation in STEM Activities

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Dor Abrahamson, University of California Berkeley, USA

Abstract

Whereas movement-based STEM learning activities garner increasing interest among designers, researchers, and policy makers, much remains unknown regarding parameters of movement-based activity design affecting learning quality. One such parameter is task-initiation, namely the questions of who decides what should be accomplished with the resources—the designer or the student—and how movement-based STEM learning programs accommodate student choice during task-initiation. In this theoretical paper, we draw on an embodied design theoretical framework to lay out the issue of task-initiation by presenting and comparing two movement-based STEM programs. In both activities, students first perform a task and then model their performance as instantiating STEM concepts, but the programs differ with respect to task-initiation. In one program, the Mathematics Imagery Trainer for Proportion, students learn to perform pre-determined motor-control tasks by developing new perceptuomotor coordinations for enacting goal movements. In another program, Playground Physics, students use real playground equipment, such as a swing, and virtual playground play performances in the app to determine their own task, such as swinging as high as possible. As such, task-initiation design considerations are tightly related to designers' overall rationales that, in turn, emanate from assumptions concerning, for example, the epistemic constitution of STEM content, the affective allure of STEM practice, manifestations of agency in STEM problem solving, and other contextual details, such as logistical, architectural, institutional, and curricular

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ORIGINAL RESEARCH
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From STEM to STEAM: An Enactive and Ecological Continuum

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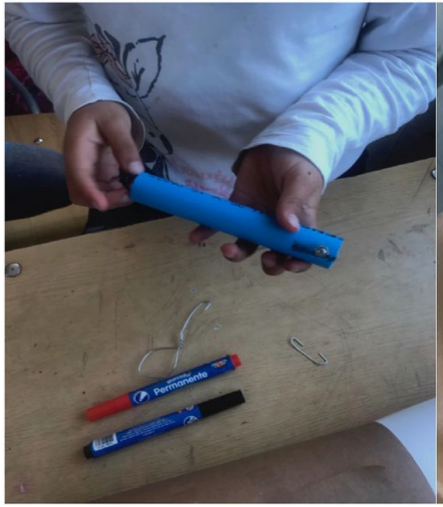
STEM and STEAM education promotes the integration between science, technology, engineering, mathematics, and the arts. The latter aims at favoring deep and collaborative learning on students, through curricular integration in K-12 science education. The enactive and ecological psychology approach to education puts attention on the role of the teacher, learning context and socio-cultural environment in shaping lived learning experiences. The approach describes education as a process of embodied cognitive assemblage of guided perception and action. The latter process depends on the interaction of learners with

Proposition: A pedagogy of uncertainty with STEAM

We make special reference to **how teachers can make their students learn from clues,** impoverished traces, or traces of information available within their learning environments to solve a challenge or problem, to the extent that they investigate, create, manufacture and/or actively participate in technology inside and beyond the classroom (Videla-Reyes, Aguayo & Veloz, 2021)



STEAM embodied design: Educators and learners laying down a path in walking with STEAM

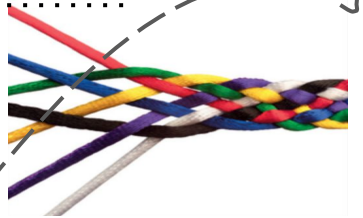
1. Identify topic (challenge or problem)

2. Co-design (collaborative work)

3. Research on the topic (inquiry and analysis)

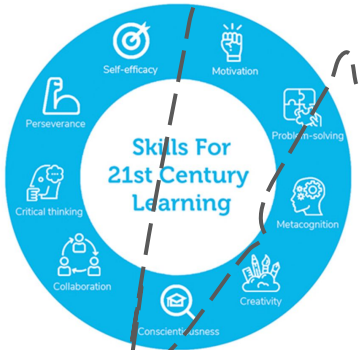
4. Select subject disciplines (decision making)

5. Make curricular integration (21st Century Skills)



Curriculum Integrated

6. Propose STEAM activities (Creativity and innovation)



7. Design STEAM pedagogical trajectory (planning and organization of activities)

Enactive learning: Laying down a path in walking with STEAM

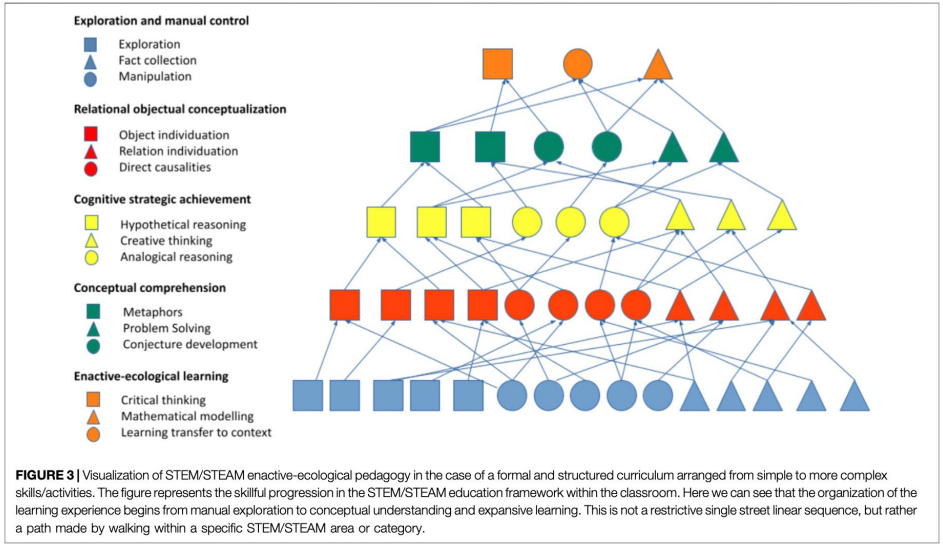


FIGURE 3 | Visualization of STEM/STEAM enactive-ecological pedagogy in the case of a formal and structured curriculum arranged from simple to more complex skills/activities. The figure represents the skillful progression in the STEM/STEAM education framework within the classroom. Here we can see that the organization of the learning experience begins from manual exploration to conceptual understanding and expansive learning. This is not a restrictive single street linear sequence, but rather a path made by walking within a specific STEM/STEAM area or category.

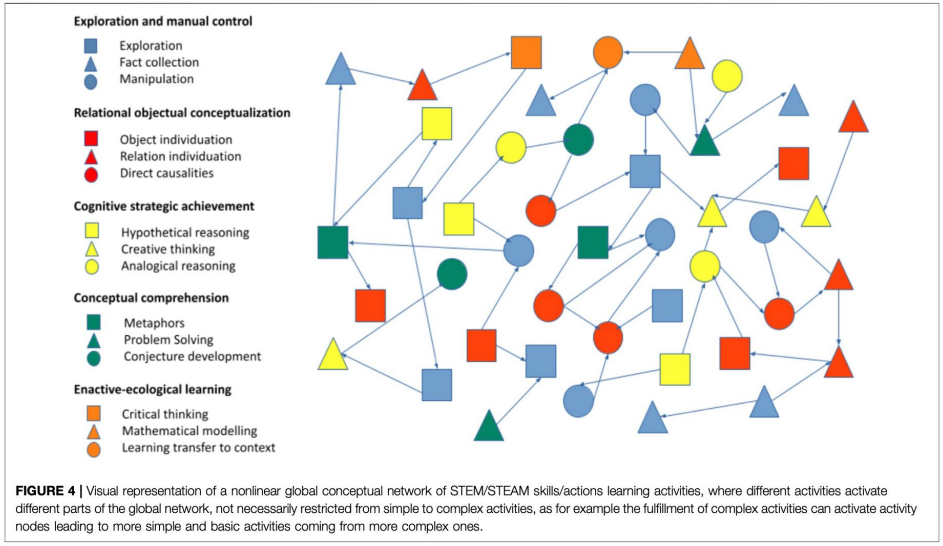


FIGURE 4 | Visual representation of a nonlinear global conceptual network of STEM/STEAM skills/actions learning activities, where different activities activate different parts of the global network, not necessarily restricted from simple to complex activities, as for example the fulfillment of complex activities can activate activity nodes leading to more simple and basic activities coming from more complex ones.

1. Identify topic (challenge or problem)
2. Co-design (collaborative work)
3. Research on the topic (inquiry and analysis)
4. Select subject disciplines (decision making)
5. Make curricular integration (21st Century Skills)
6. Propose STEAM activities (Creativity and innovation)
7. Design STEAM pedagogical trajectory (planning and organization of activities)

Summary

- Opportunities and challenges of 21st Century education occur in an uncertain and unpredictable environment, **requiring a new framework of pedagogical action** based on uncertainty

Summary

- The foundations of a pedagogy of uncertainty are **STEAM**, **embodied design**, and **enactive-ecological learning**. The design of simple to complex learning activities arranged according to the context can facilitate the learning of 21st Century integrated STEAM skills and curriculum

Summary

- With STEAM embodied design based on an enactive-ecological learning framework, **basic to complex non-linear pedagogical trajectories can be designed** for educators and learners to walk together while adapting to the uncertainties of their context as they progress through their learning.

THANK YOU

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