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Promoting Creativity in Computing Education

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Extended abstract

1. Introduction

Computing is a family of sciences related to data, information and knowledge processing (Denning et al., 1989). It is an umbrella term that covers computer science, computer engineering, information and communication technology, software engineering, and information systems. Computing education refers to any form of teaching, training, or learning activities that aim at understanding a topic within computing. Computing education research (CER) is an academic research field that develops, designs, conceptualizes, and evaluates methods, practices or phenomena in computing education. Based on its agenda, CER lies in the intersection of computing and any of its application areas, and education and any of its sub-specializations.

A computing teacher can regard him/herself a performing artist who re-enacts the basic ideas of the topic that s/he is teaching. Complementary to this agenda, s/he might also consider her/himself as a creative artist who generates new knowledge in participation with the students. The six W questions – What, Why, hoW, Where, When, and Who – distinguish a performing teacher from a creative teacher; the first one follows performing computing pedagogy and the second one creative computing pedagogy. The possibly latent agenda of a creative or performing computing teacher can be called creativity-based or performance-based curriculum, respectively.

One of the key creative methods is called distant analogies. The method enforces its users to deliberately detach themselves from conventional ways of thinking by having to adapt random words to a given, open problem. The reader of this article is called for finding a meaningful analogy from the list of words after each W question, to explore for a creative answer to it.

2. What – got, dot, JOT, hot

One of the key problems in Computing education has been that, as a discipline, the identity of Computing among and its position within other sciences has been hard to define. Due to the relatively recent and still ongoing formation process of the field of Computing as a discipline, its educators are not in their comfort zone when asked about their scientific identity and are therefore cautious or even shy to teach it in novel ways. This is seen in the decreasing interest among high school students to choose computing as their career. Computing does not seem to have an attractive, inspiring reputation as a study field.

From the educational point of view, a fruitful perspective is to define computing as a specification science. Hence, a computing professional's competence is to compose requirements for various digital services. In a way, s/he is a match maker between the available or possible-to-design technologies and the explicit or implicit expectations of a particular application instance. This requires skills in identifying a problem, talking with people, drafting solutions and coming up with a final specification, the detail level of which varies from algorithms to real systems.

In essence, specification is a matter of creative problem solving and problem management (Polya, 1945). The attribute 'creative' refers to openness and novelty – there should be no unnecessary constraints in identifying problems, their solutions, applications, or evaluation criteria. Even the problem statement itself – if even given – should be open for diverse interpretations. Problem management stands simply for an extension of the plain solving process: identification and evaluation of solutions are equally important phases of a problem management process.

Creativity should lead into innovation: creative solutions should result in novel insights in terms of concrete products, services, or practices. In fact, the importance of the pragmatic, innovative aspect of creativity, and specifications for that matter, is related to contextualization. The innovations should make sense and a difference in a given environment or socioeconomic situation that we call the context of innovation (Figure 1).

Understanding Computing as a specification science has consequences for teaching and learning computing. Creative computing pedagogy targets at students' learning contextualization, also when learning traditional elements of the Computing curriculum.

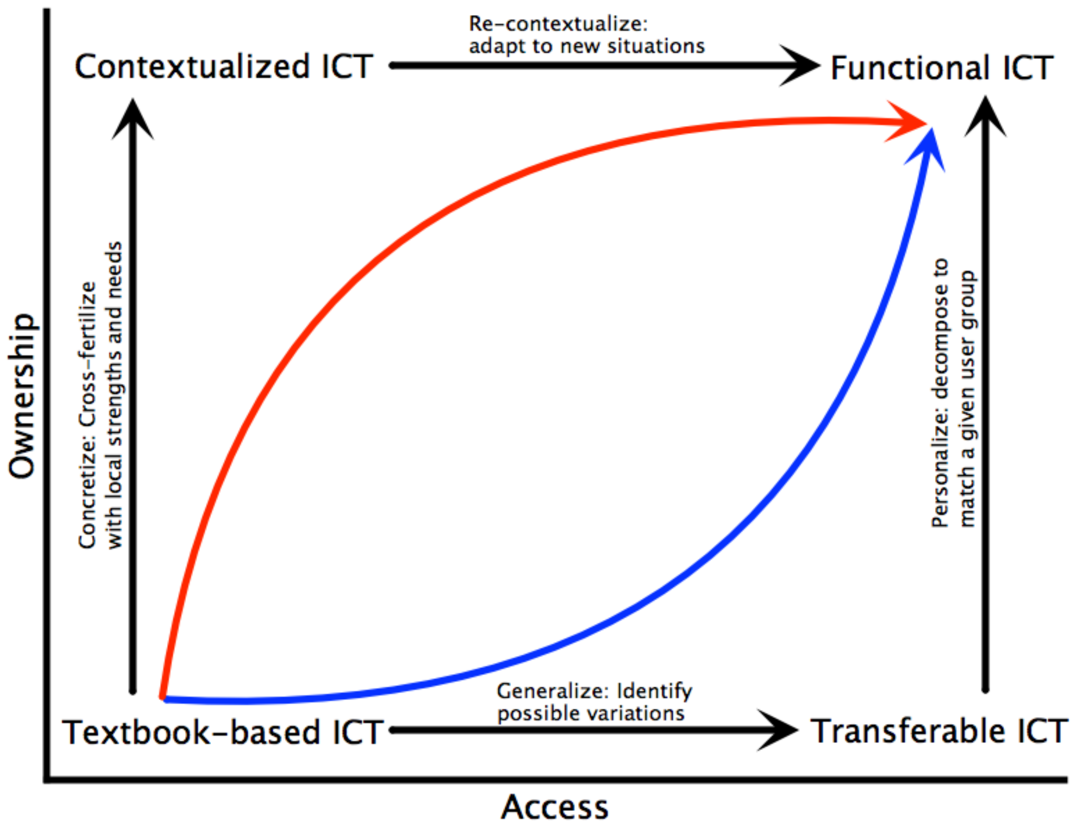

Figure 1: *Two paths towards functional information and communication technology (ICT). The upper path emphasizes creative pedagogy and the lower one performing one (Sutinen & Tedre, 2010)*

3. Why – shy, my, lie, guy

The 'why' question asks for the targets of, or values behind, creative computing pedagogy. Interestingly, this can be analyzed by referring to diverse theories of truth, because reaching the truth is a fundamental goal, and hence value, of any discipline. The four different truth theories, those of pragmatism, coherence, correspondence, and consensus, relate closely to four different mother sciences of computing: engineering, mathematics, natural sciences, and social sciences, respectively.

Table 1 illustrates how the distinction between creative and performing computing pedagogy generates differences in following the values informed by different truth theories. The consequences for practical teaching and learning are apparent. Moreover, the selected pedagogical approach has implications that reach further, like training professional competences, promoting the ownership of profession, and student recruitment.

Table 1: *Impact of the underlying truth theory to what is expected from computing. Examples show how creative and performing teachers interpret the expectations in their education*

Truth theory	*Truth is defined as…*	*Expectations from Computing in creative pedagogy*	*Expectations from Computing in performing pedagogy*
Pragmatism	What works	Agent of change	Reliability, efficiency
Coherence	What is internally coherent	Aesthetic principles and artifacts	Theory of computation
Correspondence	What corresponds to the external world	Modeling empirical observations	Meeting the given specifications
Consensus	What can be agreed upon	Functional systems based on participatory design	Standardization

4. How – low, cow, wow, bow, Bauhaus, row, sow

There are several opportunities to embed creativity into a Computing curriculum. Creativity can be a cross-cutting theme of the whole curriculum. If creativity has an impact on every aspect of the curriculum and its implementation, we can talk about creativity-based learning.

A compromise between creative pedagogy and performing pedagogy is to include one or two creative problem management courses in the curriculum. This approach can be enhanced by having the students to work for their projects in living labs. For instance, Kids' Club is an environment where school children work together with computer science students and researchers and companies for innovative solutions. The piazza type of platform inspires also students to fully utilize their creative minds. (Eronen et al., 2005).

In the online or blended learning scenarios for Computing, creative pedagogy requires learning repositories or digital contents where individual learning objects (aspects, components) are linked by creative associations with each other. To further this towards innovative pedagogy, the creative associations need to be aligned with the context.

5. Where – there, heir, fair, fare, dare, care

The 'where' question of our analysis focuses on the context where creativity is required. In short, contextualization emphasizes the crucial role of context as the starting point of creative pedagogy of Computing. Whatever a student is learning, s/he needs to be able to relate it to his/her immediate context, but later also to contexts to come throughout the career. This means that the student also needs to learn re-contextualization.

Taking into account the factors of a particular context can be done in several ways. For example, a design method can start from the needs of the context, or alternatively, its talents that refers to the explicated strengths that the context feels responsible for. Table 2 illustrates, in the application area of ICT for development, how the talents-based approach calls for creativity, while the traditional needs-based design process starts from various recommendation lists given in policies, strategies, or theories.

6. When – hen, then, yen

The time orientation in Computing education can refer to the appropriate school phase (K12, college, continuing education, JOT learning) when various topics are learned, or the perspective that determines the focus of learning activities. In general, performing pedagogy sets emphasis to the timing of the teaching, whereas creative pedagogy is flexible, and also invites learners at different phases to collaborate with each other. In addition, performing pedagogy is concerned about teaching too early or too late. In fact, adaptive learning environments or intelligent tutoring systems are usually based on the principles of appropriate timing, determined by the outcomes of and the prerequisites for learning a given topic.

By the other regard, learning can take place

- for the *future*: innovations can be derived from the future, abductively, or scenarios can be generated deductively or by prediction;
- at the *moment* so that improvisation becomes a key learning method; or
- based on the *time passed*: learning from experiences, associations, and induction.

Compared to performing pedagogy which emphasizes learning the given contents at an appropriate time, creative pedagogy makes better use of time orientation as generating the stage for learning. In fact, varying the time perspective between what was, what is, and what will be stimulates creativity.

Table 2: *Talents-based approach emphasizes contextual and creative design. ICT4D refers to ICT for development. Adapted from Sutinen (2010)*

MOTIVATION	NEEDS-BASED	TALENTS-BASED
USE	Import and transfer of ICT4D; dumping solutions Example; Introduction of Facebook	Constructive and innovative evaluation of existing technology Spin-offs/unexpected uses of existing technology Example; Use of *Voicebook* for giving voice to people.
DEVELOPMENT	Conservative ICT4D Localization of solutions according to the needs of the people Innovations are rare Example; Localization of Facebook to meet the needs of a community.	Innovative solutions Real inclusion of local people to the development process Example; A novel tool (e.g. *Voicebook*) for the benefit of the community.

7. Who – do, you, too, sew

In every educational setting, it is important to identify the roles of all the participants: teachers, students, and several other stakeholders. Quite expectedly, performing pedagogy pays attention to the clear roles of the people involved in a learning process. This does not mean, though, that only a teacher should perform; also a student or a group of students can give a demonstration, or an expert from industry can be invited to give a guest presentation. In any case, a learning setting is well prepared and organized to cover a given topic.

Creative pedagogy supports the organic character of a learning situation in a context where different participants struggle together for an informed progress. This means that the role allocation is collaborative whereas the one in performing pedagogy is based on co-operation. Everyone is called for contributing by his/her talents. Creative pedagogy gives a voice also to shy people for them to express themselves.

Table 3: *Performing computing pedagogy vs. creative computing pedagogy*

	What	Why	How	Where	When	Who
Performing computing pedagogy	Computing as defined in the ACM/IEEE curriculum	Efficiency, correctness, and reliability	Theory-driven examples of applications	Everywhere, ex cathedra; needs-based	Appropriate timing for given contents; deduction	Individual performers, tops
Creative computing pedagogy	Computing as a sense making specification science	Growing a spectrum of competences	Authentic assignments in living labs, or labbing lives	For a particular context; talents-based	Varying time orientations to set a stage for creative learning; induction, abduction	Learning community, hip hops

8. Conclusion

The role of creativity in Computing education is significant to several aspects of the curriculum. Table 3 compares the performing computing pedagogy to creative computing pedagogy by the six Ws. It shows that it is too simplified to identify performing pedagogy to teacher-centeredness and creative one to learner-centered education or problem-based learning. For instance, problem-based learning does not require contextualization, as does creative pedagogy.

Exercise

Discuss creativity in terms of a (finished) product/message/opus and a (initiated or on-going) process/method/tabula rasa. What could be, if anything, creation ex nihilo in computing? Does creativity refer to 'the created', 'the creative', or 'that to be created'?

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