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Thematic Working Group 6

Advancing computational thinking in the 21st century

Summary Report and Action Agenda

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1. Background: Setting up the stage

It has been argued that "Computational thinking represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use" (Jeannette Wing, 2006, p. 33). In addition, Wing argues that this new competency should be added to every child's analytical ability as a vital ingredient of science, technology, engineering, and mathematics (STEM) learning. Several professional bodies and think tanks in the US, the UK, and the Netherlands have called for more attention to CT in the curriculum.

Despite this interest in CT there are a range of issues and challenges facing us as we attempt to integrate CT in the curriculum. They range from foundational issues such as even defining what we mean when we speak of CT, to what the core concepts/attributes are and their relationship to programming knowledge; how these concepts/attributes are to be assessed; how it should be taught to students; what its developmental progress is (if any); how teachers are to be trained to effectively integrate CT in their classrooms; and finally the kinds of research that needs to be done to further the CT agenda in education.

2. Recommendations

One of the fundamental challenges faced by CT is the lack of clarity about what we mean when we say CT. Thus at one level the group questioned the very name of the domain – by deconstructing what we mean when we say "computation" and what we mean when we say "thinking." It was argued that CT was about problem solving, problem finding, analyzing data, representing data, using algorithms and so on. And it was also about being creative, collaborative, as well. This leads to a fundamental disconnect about the very idea of CT.

At the micro level, CT can be seen as learning to program the computer (using some specific programming languages) while at the macro level we have a broad set of "ways of thinking" (such as systems thinking, problem solving, algorithmic thinking etc.). The group argued that the former (learning to program) was too narrow while the latter (the ways of thinking approach) was too broad to be useful. Furthermore it is not clear how the ways of thinking approach can be usefully distinguished from other 21st century skills such as abstraction and creativity.

The group at EduSummIT2013 focused on CT suggested that the field needs to develop a better definition of CT, one that emphasizes the ability to not only solve problems with computers but learning to "speak" to computers. Thus CT was seen as being distinct from "working" with a computer (such as for creating a movie or writing a paper) to being able to "control" the computer. It was also suggested that CT needed to be more than learning to program and that the application of CT needs to be seen in diverse fields (not programming for the sake or programming) such as science, art, mathematics, robotics, etc. An important aspect of CT was seen as being the ability to augment human capabilities by learning to "manipulate" the abilities of digital technologies and beyond that to identify the appropriate technical and physical tools and understanding in how to apply multiple tools in appropriate ways to solve problems and/or develop solutions in a person/tool partnership (a form of distributed cognition).

The group also developed a "first draft" list of attributes of CT. These include:

- Analysis of problems & artifacts
- Algorithmic approaches to problem solving
- Movement between different levels of abstraction & representation
- Familiarity with decomposition, emphasis on modularity
- Development of computational artifacts
- An Understanding of data-structures and information structures
- Design thinking (reverse engineering) - how it is going to function
- Emphasis on debugging

Another area that the group focused on was how these attributes could be measured – i.e. could we identify behavioral co-relates to these attributes. One of the advantages of working with digital media is the "traces" that users leave behind. It was suggested that future work in the area develop techniques/analytics for "mining" these traces to assist in the evaluation and assessment of CT skills. Though there is still a lot to be done in defining CT (specifically in distinguishing CT from other cognitive competencies) the group believed that we had made a good step forward in this area through our discussions.

3. Action plans

A range of action plans were suggested. Broadly, the goals were as follows:

- Develop a conceptual framework
    - Define (what it is and what it is not)
    - Develop a common vocabulary
    - Identify "parallel" movements / organizations

- Develop measurable attributes
- Develop a scope and sequence, in order to achieve the most efficient and effective combination of steps and resources
- Identify research approaches and opportunities
    - In particular focus on what aspects of CT transfer to problem solving/ problem seeking approaches in other areas
- Identify the audiences
    - Teachers / Teacher Educators; Computer scientists / Informatics specialists; Policy makers/ Administrators; Maker movement and other informal learning groups; Industry

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