Understanding Collaborative Computational Thinking

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**ABSTRACT**

One of the overarching processes defining the future is the digital revolution: impinging on, reshaping, and transforming our personal and social lives. Computation and communication are at core of this change, transforming how problems are defined and solutions are found. To be successful in the 21st century, skills such as Computational Thinking (understanding and applying computational concepts) are beneficial for learners at all ages and disciplines. One can learn computational concepts by taking a traditional course offered in a school or by self-guided learning through an online platform. Whatever the form of learning, learning computational concepts can be difficult for novices. Collaborative learning has been considered effective in reducing learner’s anxiety and in helping struggling learners to overcome common learning difficulties. By focusing on social interactions taking place between group members, my proposed dissertation study aims to investigate how collaboration impacts the learning of Computational Thinking, both in classroom settings and also in online learning communities. This paper briefly describes the motivation and outline of my proposed dissertation study, the overarching research questions, the data currently collected, and my data analysis methodologies.

**Categories and Subject Descriptors**

[**Computers and Education**]: Applied Computing,-Education- Collaborative learning [[1](#_ENREF_1)]

**Keywords**

Computational Thinking, collaborative learning, novice learner, social interactions

# PROGRAM CONTEXT

I am a third year PhD student in the Department of Engineering Education at Virginia Tech University. I have passed my Qualifier and Preliminary Examinations. Now as a PhD candidate, I am developing my research proposal, describing the background, purpose, methods, anticipated outcomes, and contributions to the field of my work. I have conducted a pilot study in fall of 2014. Recently (spring 2015) I have collected data on novice learners’ collaboratively learning computational concepts in a classroom setting. Separately, I have also explored the dataset of an open, online learning environment (scratch.mit.edu).

# CONTEXT AND MOTIVATION

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One of the overarching processes defining the future is the digital revolution, impinging on, reshaping, and transforming our personal and social lives. Computation and communication are at the core of this change and are transforming how problems are defined, and solutions are found and implemented. Computer modeling, simulation and visualization software, Smart grid, and Software Defined Radio, are a few examples where computation has allowed us to tackle problems from varied perspectives. Vast domains await discovery and mapping through creative process of CT which would provide us with the ability to “find the right technology for a problem and apply technology to resolve the problem”[[2](#_ENREF_2)].

As the use of computation spreads across domains, learners of all ages and backgrounds are being urged to learn fundamental computer science concepts (e.g. abstraction, iteration, conditional logic, algorithms, functions, parallelization, etc). However, novice learners struggle to learn and apply these concepts. As educators in Computer Science, it is important for us to determine effective pedagogical approaches to familiarize novice learners to fundamental concepts of computer science.

Collaborative learning has been considered effective in reducing learner’s anxiety and in helping struggling learners to overcome common learning difficulties. However, there is limited understanding as to how the collaborative process of learning impacts learning of CT. One way of understanding the collaborative dimension of learning is by analyzing the social interactions among members of a group of learners. For example, when a group of students code and debug a program together in a class or when students share, comment or reuse pre-existing code from each other in an online learning platform. The proposed dissertation study intends to analyze the social interactions between members of groups in order to better understand what novice learners struggle with and how collaborating with others influences their learning.

# BACKGROUND & RELATED WORK

The definitions of CT provided by Wing [[3-5](#_ENREF_3)] and the operationalized versions [[6](#_ENREF_6)] emphasize CT as an ability to formulate and solve problems using information representations and automated processing. Abstractions, iterations, conditional logic, algorithmic thinking, parallel computing are considered fundamental concepts of CT.

Different initiatives for integrating CT within existing curricula have started to gain footing. Most initiatives have been at the K12 level. However, some universities are integrating CT modules throughout their undergraduate program whereas others are offering it as a semester long course. Some of these courses are being offered with a particular discipline viewpoint, while others are general education courses designed for all non-computers science majors. Online learning platforms (e.g. Scratch, Alice, Blockly) have also been considered to foster learning of CT. The emphasis of teaching has ranged from learning CT in contexts versus learning across context, a cognitive ability versus an application of skills, as a problem solving tool, or as an alternative approach to creatively express one’s ideas. Along with high level programming languages such as Python, CT courses also use block-based programming languages such as Blockly, Alice, or Scratch to make CT easier for novice learners. The pedagogical approaches seem to be limited to solving programming problems, digital storytelling, and game design. Students learn CT individually as well in groups. However, assessment related to CT has mostly been done at the individual level.

# STATEMENT OF THESIS/PROBLEM

The overarching goal of the proposed dissertation study is to better understand the collaborative process of learning CT. In order to do so, the proposed dissertation aims to look into CT from three standpoints. The following paragraphs describe each of these standpoints, the data that will be used, and the proposed analysis methods.

**The first** part of the study will investigate existing literature and synthesize the implications and pedagogical approaches of learning and assessing CT (particularly at the university level).

Data: Literature review

**The second** part of the study will investigate the collaborative aspect of learning CT in a classroom setting. This qualitative study will focus on better understand how social interactions within a group of learners impact learning of CT.

Data: Audio and video recording of 3 student groups collaboratively learning in an undergraduate general education CT course. Total of 6 class sessions (each session is 20 minutes; total of 120 minutes have been recorded.

Analysis: The video recordings of group collaboration will be analyzed. Event based analysis of encounters will be done on the video recording based on an observation check list and also using Chi’s framework of differentiating learning activities [[7](#_ENREF_7)]. The observation check list used for analysis will illustrate the patterns of social interactions members within a group exhibit while learning CT. Additionally, Chi’s framework would allow collaborative CT activities to be categorized as active-constructive-iterative. According to Chi, interactive activities are better than constructive activities and constructive activities are better than active activities.

**The third** part of the study will investigate the collaborative aspect of learning CT in an open online community. The focus of this part of the study is to better understand how social interactions (e.g. following, commenting) and re-using another users code impact a learners ability to create projects (a creation made in Scratch program) using computational blocks (puzzle-piece shapes that are used to create code).

Data: The dataset of Scratch online community will be used for the third part of the proposed dissertation manuscript. Scratch (www. scratch.mit.edu) is an online community and social networking forum. In this platform, youths (typically ages 8-16 years) code games, animations, and stories using a media-based programming language. Scratch has been designed to support the development of CT in young people. The dataset includes 1.9 million projects from 1 million users. Projects are available from 2007 to 2012.

Analysis method: Exploratory factor analysis (based on type and no. of blocks used, no. projects created, no. of remixed projects of a user, user’s community age). Also applying network analysis (different visualizing layouts, setting different path lengths, node size, betweeness centrality)

# DISSERTATION STATUS

For the classroom part (second part of my dissertation) I have collected video recordings of 3 groups (each group has 4 to 6 students) for 6 days and interviewed 8 students individually. Initial coding of student interactions have been completed. My initial findings suggest a number of interesting conclusions: self-explanation/thinking-out-loud while learning CT helps students to better understand the concepts; being able ask questions to someone who is at the level of learning helps students also helps understanding concepts; many students compare learning CT to learning a new language; novice learners often become frustrated while writing code because they have to be extremely precise.

For the online learning environment (Scratch data), I have created initial relationship tables and generated basic statistical reports. Initial findings suggest that novice Scratch users tend to remix others code and make minor adjustment to the code. I have not yet generated or tested any hypothesis.

I have completed a draft of my dissertation proposal which describes the background, purpose, and methods of my proposed dissertation study, the outcome anticipated, and the contribution to the field. I plan to defend my dissertation in the beginning of September, 2015, complete writing my dissertation between September-November, 2015 and defend early (January/February) 2016.

# EXPECTED CONTRIBUTIONS

The outcome of this study will explain what novice learners struggle with while learning CT and how social interactions impact their learning. The study will also provide a framework that illustrates the collaborative aspect of learning CT.

# REFERENCES

1. NRC,Report of a Workshop on the Scope and Nature of Computational Thinking. 2010: National Academies Press.
2. NRC, *Report of a Workshop on the Pedagogical Aspects of Computational Thinking*. 2011: The National Academies Press.
3. Wing, J., Computational thinking. Communications of the ACM, 2006. 49(3): p. 33-35.
4. Wing, J.M., Computational Thinking--What and Why? In thelink. 2011, Carnegie Mellon University School of Computer Science. p. 8.
5. Cuny, J., L. Snyder, and J.M. Wing. 2010. Available from: http://www.cs.cmu.edu/~CompThink/.
6. College Board and NSF. The College Board Computer Science: Principles Computational Thinking Practices Big Ideas, Key Concepts, and Supporting Concepts. 2011. Available from: http://www.collegeboard.com/prod\_downloads/computerscience/ComputationalThinkingCS\_Principles.pdf.
7. Chi, M.T., Active‐constructive‐interactive: A conceptual framework for differentiating learning activities. Topics in Cognitive Science, 2009. 1(1): p. 73-105.