Computational Thinking

Terri Evans

New Jersey City University

October 28, 2018

Background

Computational thinking is defined by the International Society for Technology in Education as a problem solving process. It includes organizing and analyzing data, use of models and simulations to represent data, automating solutions through algorithmic thinking, transferring the problem solving process to multiple situations and formulating problems in a way that facilitates use of a computer to help solve them. Essential to learning computation thinking skills, are many other executive functioning skills that support a student's ability to adapt and follow through in all areas of their lives. As a function of developing strong computational thinking skills many other skills are developed including: confidence, persistence, tolerance and communication (Sykora, 2014).

Computational thinking is no longer limited to computer science. The 21st century global economy required educators more skilled at incorporating: decomposition, generalization, algorithmic thinking, and abstraction across educational content areas. Ongoing, embedded opportunities for professional growth is needs for educators to begin to incorporate computational thinking into courses beyond the traditional computer science courses (Randles, 2018).

The global economy is not able to fill enough jobs for knowledge workers. There is decreasing opportunity for employment for students who lack 21st century skills: problem solving and critical thinking among them. A target of education in centuries past, was to produce those who would work in the industries that that were plentiful. Today, in our fast paced, technology driven world, all most computational thinking skills are needed in all industries because they are skills that are used to solve problems. Solving problems is not unique to

traditional computer science interests. There earlier the skills are introduced, the more practice students will have, the better at it they will become.

Research Questions

1. What do teachers believe is the role of computational thinking in K-12 education and how can they expand use of or the introduction of computational thinking concepts in their classes and sustain inquiry?
2. How do teachers assess computational thinking skills during and after instruction?

Methods

The study will exam how computational thinking skills are perceived by teachers, how these skills are inserted into the classroom and how they are assessed. The population is 5th grade classes at an urban middle school. Approval from the board of education is required, as well as, teacher opt in and permission slips returned from students. A formal request will be drafted to submit to the board of education requesting permission for the study and purposeful sampling will be used to derive the sample from the population. The sample will be determined based on these methods Creswell 1998). The qualitative approach is expected to uncover teacher dispositions regarding computational thinking for students and insight into how success with computational thinking is measured. A phenomenology approach will be used to examine teacher beliefs and classroom expectations. Data collected will include teacher interview, survey, classroom observation and collection of student artifacts used to demonstrate understanding. The data will be coded to categorize teacher knowledge about computationaling thinking thoughts about computational thinking, and to determine who previous knowledge and thoughts impact student experience based on observation (Patton 2015). Teachers will be selected and participants will be interviewed and provided with a survey to complete. Classroom

observations will be scheduled over a period of 4 weeks and the number of classrooms being observed will be determine my the number of teacher participants. One concern is not knowing whether the request will be granted and whether or not teachers will have concerns about records of their responses being viewed by others not interested in the study. Class schedules could also have a negative impact on timely completion of the study depending on the time of year the investigation takes place. Observations in even a handful of classrooms could take several weeks to complete.

Literature Review

The literature on computational thinking identifies several areas of concern as well as identified areas of promise for positive student outcomes. Much of the literature investigates teacher preparation. Other studies investigate classroom activities and structures that provide computational thinking learning opportunities.

Bower (2017) investigated how teachers could best be supported in their development of computational thinking pedagogy. The global demand for STEM introductions in the school system required teachers who have the capacity to lead the instruction. The study of computational thinking adds recognition of computation and the application of computer science in understanding the world. in the world and the application of computer science to understanding and solving problems. With so many things connected to the internet at home and at work, students are in continuous contact with technology as part of the global economy. "Systemic change" is warranted if the goal of preparing children of all ages for fields requiring computational thinking skills. "If teachers have inaccurate and native perceptions of computational thinking, it will directly influence how they teach this area" . p. 53 Teachers many not be comfortable teaching the concept and resources for support are scarce.

Jaipal_Jamini & Angeli (2017) identify increasing requirements for the infusing of STEM in k-12 education leads to examination of how preservice teachers are being prepared to teach STEM subjects. Findings reported an increase in interest and developing understanding of science concepts and related computational thinking concepts as a result of participation in the robotics course (science methods). The robotics course increased self-efficacy to teach robotics. Global economic demand for knowledgable students in STEM fields continue to rise and many countries seek ways to positively support STEM education for K-12 students. In order for teachers to support student acquisition of STEM skills, teachers must be confident in their skills to teach with these approaches. Self-efficacy is believed to have a large role and mastery experiences seem to improve computational thinking and self-efficacy.

Leonard, Mitchell, Unertl, Robinson, Hester-Croff (2018) studied teaching preparation in regards to engaging students in computational thinking when teacher preparation included robotics, game design or a combination of both. Teacher self efficacy in this study was only gained when teachers participated in robotics or robotics and game design combined. The research examined teacher preparation and change in beliefs about facilitating STEM practices with under represented groups in informal school settings and the promotion of "rich content, high-quality instruction, collaborative peer relationships, and STEM identities. Culturally responsive teaching was used to influence teaching attitudes and STEM practices. None of the the teachers used culture as a learning motivator in robotics or game design. CT is defined by ISTE and CSTA as a "problem-solving process that includes formulating problems, logical organization of analysis of data, representation of data through abstractions, identifying and automating solutions through algorithmic thinking, analyzing and implementing possible solutions, and generalizing and transferring the problem-solving process. The "simplest form of

expressing computational thinking is writing code to use abstraction, algorithmic thinking, and learning transfer in game design. In this study teachers improved self-efficacy. Computational thinking understandings increased. Teachers exhibited equitable STEM practices and culture was evident in teacher practices.

Kaleioglu, Gulbahar, Kukul (2016) describe computational thinking as increasingly being identified as an important skill for all in this digital age. This study examines activities included in a computational thinking curriculum and defines computation thinking based on several sources. Game-based learning and constructivism were found to be the theories that most represented the foundation and formation of computational thinking instructional targets. Previously, computer science was considered to be specific to particular disciplines, however, in the current digital climate when even household devices are connected to the internet, and many individuals own one or more devices that provide for global connections, it is well accepted that the time has come for a new point of view. Discussions must engage how to teach it, how to assess it and how to apply it to real-life. Concepts of abstraction, algorithmic thinking, problem solving, pattern recognition and design-based thinking top the list of most valued skills.

Wu (2018) studied the development of computational thinking skills that emerged from student participation of game design activities. Constant access to data of multiple modalities require learners to have conventional literacy skills in addition ao digital and technological literacy skills in order to “effectively navigate the boundless world of information”. Computational thinking skills are required to fulfill this concern. In this study the pedagogy used for the game design curriculum was written with intentional focus on the development of computational thinking skills as part of the game design activities. The study is described by Wu as a “work in progress” with much to be gained by further investigation into the use of game play

for fun and to learn and how to and what tools to use to "help 21st century learners not just learn to use and think with technology but to create and critique with technology?"

Aksit (2018) believes students should be exposed to computational thinking in middle school science classrooms. It is an "authentic" practice used by scientists and engineers in their daily work. Computational thinking and simulation-based model building through visual block programming. This had a positive impact on student understanding of force and motion. Specific interventions (block based programming) shapes student attitudes positively toward computational and increases positive learning outcomes. It is generally agreed among scientists and engineers and many educators that computational thinking is a needed skill for all students. Technology and computational tools are part of everyday life in the 21st century. Computational thinking is a process of solving problems step by step. Middle schools face a shortage of teachers to teach introductory computer science but what does exist computational thinking in game design, storytelling and programming. Engaging students in modeling and scientific and computational tools is at the center of the inquiry based classroom, however, students have little experience with it and therefore skill development is not strong. Block based programming facilitates thinking in different ways. Block based programming is a pathway to computational thinking practices. Visual programming allows students to construct computer models that improves student understanding.

Tran (2018) states that digital natives may use computational thinking skills to "conceptualize, analyze, and solve complex problems across content areas. Students benefited from early introduction to computational thinking and its application across subjects and everyday life. The global economy has demand for students and workers with CS and CT skills for jobs that increasingly rely on and make use of technology. Early adoption in elementary

schools provides students with economic and intellectual opportunities for competency with CS activities.

Sepehr (2014) examines access to opportunities to engage in computational thinking activities for urban middle school students. He work distinguishes a conversation about access of computer technology to access to the knowledge that surrounds computational thinking and the requirement that it is for access to higher education, employment and for becoming an "active and informed participant in society". Technology has become available, opportunities for computational thinking learning opportunities have not for ruban schools where there are a large number of low income students for color. Research found "curriculum that fail to adequately connect to the lived experiences of urban students." Students in these populations benefit from curriculum that is inquiry-based and focuses on "theories of learning where issues of identity and personal agency are considered critical for student engagement. Focus on "politically relevant applications of technology within urban communities" increases the level of engagement.

Booth (2013) studied the impact of a NSF computational thinking course for undergraduate non CS majors. Problem abstraction, decomposition, fundamental programming concepts were added to the traditional information technology course. Booth found that when computational thinking was added to courses, students increased the use of computational strategies for problem solving activities. Both also found that computer anxiety was reduced and self efficacy using computing thinking skills increased.

Conclusion

From elementary school through post secondary education, but inquiry of applying computational thinking skills to solve problems is a complicated undertaking. Attitudes and beliefs of the teacher have a significant impact on how computational thinking is acquired and

may have an impact on student perceptions as well. Further study may reveal how student responses to computational thinking are affected by a teacher's self efficacy.

References

Aksit, O. (2018). Enhancing science learning through computational thinking and modeling in middle school classrooms: A mixed methods study (Order No. 10969743).Available from ProQuest Dissertations & Theses Global.(2089075150). Retrieved from https://draweb.njcu.edu/login?url=https://draweb.njcu.edu:2052/docview/2089075150?accountid=12793

Booth, W. A. (2013). Mixed-methods study of the impact of a computational thinking course on student attitudes about technology and computation (Order No. 3567832). Available from ProQuest Dissertations & Theses Global. (1422410095). Retrieved from https://draweb.njcu.edu/login?url=https://draweb.njcu.edu:2052/docview/1422410095?accountid=12793

Bower, M., Wood, L. N., Lai, J. W. M., Howe, C., Lister, R., Mason, R., … Veal, J. (2017). Improving the Computational Thinking Pedagogical Capabilities of School Teachers. Australian Journal of Teacher Education, 42(3), 53–72. Retrieved from http://draweb.njcu.edu:2048/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1137876&site=ehost-live

Hennessey, E. J. V., Mueller, J., Beckett, D., & Fisher, P. A. (2017). Hiding in Plain Sight: Identifying Computational Thinking in the Ontario Elementary School Curriculum. Journal of Curriculum and Teaching, 6(1), 79–96. Retrieved from http://draweb.njcu.edu:2048/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1157439&site=ehost-live

Jaipal-Jamani, K. kjaipal@brocku. c., & Angeli, C. (2017). Effect of Robotics on Elementary Preservice Teachers' Self-Efficacy, Science Learning, and Computational Thinking. Journal of Science Education & Technology, 26(2), 175–192. https:/draweb.njcu.edu:2106/10.1007/s10956-016-9663-z

Kalelioglu, F., Gülbahar, Y., & Kukul, V. (2016). A framework for computational thinking based on a systematic research review. Baltic Journal of Modern Computing, 4(3), 583-596. Retrieved from https://draweb.njcu.edu/login?url=https://draweb.njcu.edu:2052/docview/1810312661?accountid=12793

Leonard, J., Mitchell, M., Barnes-Johnson, J., Unertl, A., Outka-Hill, J., Robinson, R., & Hester-Croff, C. (2018). Preparing Teachers to Engage Rural Students in Computational Thinking Through Robotics, Game Design, and Culturally Responsive Teaching. Journal of Teacher Education, 66(4), 386–407. https://draweb.njcu.edu:2106/10.1177/0022487117732317

Randles, J. (2018). The 9 hottest topics in edtech. Retrieved from https://www.iste.org/explore/articleDetail?articleid=674&category=Education-leadership&article

Sykora, C. (2014). Computational thinking for all. Retrieved from https://www.iste.org/explore/articleDetail?articleid=152

Tran, Y. (2018). Computational Thinking Equity in Elementary Classrooms: What Third-Grade Students Know and Can Do. Journal of Educational Computing Research. https://doi.org/10.1177/0735633117743918

Vakil, S (2014) A Critical Pedagogy Approach for Engaging Urban Youth in Mobile App Development in an After-School Program, Equity & Excellence in Education, 47:1, 31-45, DOI: 10.1080/10665684.2014.866869

Wu, M. L. (2018). Educational Game Design as Gateway for Operationalizing Computational Thinking Skills among Middle School Students. International Education Studies, 11(4), 15. doi:10.5539/ies.v11n4p15 Retrieved from https://eric.ed.gov/?id=EJ1175221

Appendix A

Teacher Survey

Open Ended Responses

1. What is computational thinking?

2. What are the 4 cornerstones of computational thinking?

3. Why is computational thinking important?

4. What is computational thinking algorithm?

5. Is computational thinking programming? Why or Why not?

6. What resources are available to assist with insertion of computational thinking in the classroom?

7. What classroom lessons or activities allow students to explore computational thinking skills?

Appendix B

Teacher Survey B

Likert Scale Responses

1. A student's ability to use computational thinking skills to solve problems is a critical skill of digital citizenship in a global economy.

Strongly Agree Agree NeutralDisagree Strongly Disagree

2. Students in the classroom have ample opportunities to utilize computational thinking skills.

Strongly Agree Agree NeutralDisagree Strongly Disagree

3. I know where to find resources that can be used in the classroom to add computational thinking resources to my lessons.

Strongly Agree Agree NeutralDisagree Strongly Disagree

4. I don't believe it is necessary for students to use computers in the classroom.

Strongly Agree Agree NeutralDisagree Strongly Disagree

5. Students already know everything they need to know about computers in the the classroom.

Strongly Agree Agree NeutralDisagree Strongly Disagree

6. I am comfortable facilitating students creating with computer technology.

Strongly Agree Agree NeutralDisagree Strongly Disagree

7. Using a computer for instructional purposes is easy for me.

Strongly Agree Agree NeutralDisagree Strongly Disagree

Appendix C

Letter of Permission

Public Schools
Board of Education

Dear Board President,

I am an educational technology leadership student studying teacher beliefs and classroom implementations of computational thinking. I request permission to interview and observe teachers and students willing to participate in order to gain understanding of the factors that impact the delivery of computational thinking activities in the classroom.

I would appreciate an opportunity to provide resources by way of inquiry findings and to possibly widen a path to continued student success. I look forward to a positive response.

Sincerely,

Terri Evans