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Integrating Computational Thinking into Technology Courses for School and Youth Services Librarians

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Abstract:

This paper will present findings and share the experiences of the authors initiating a dialogue for change in both Library and Information Studies (LIS) curriculum and in professional library practice by integrating computational thinking (CT) into youth services courses in two LIS programs in the United States (U.S.) to promote integration of CT into youth programming and instruction in school and public libraries. These courses, part of Phase II of the Libraries Ready to Code (RtC) initiative, were redesigned with the help of a six-member faculty cohort and liaisons from the American Library Association (ALA), the iSchool at the University of Maryland, and Google. The faculty participated in two workshops, online meetings, and asynchronous collaborative exercises to learn about computational thinking, to brainstorm ways to integrate CT into their courses, to design modules or class activities involving CT, and to share their experiences of implementing CT in their courses. This paper focuses on two of the six CT course redesigns and describes the CT integrations into the youth services courses.

Keywords: computational thinking, curriculum revision, youth librarianship

Introduction

Computational thinking (CT) has been identified as a systematic problem-solving process involving the formulation of problems in such a way for a computer to understand. Traditionally CT has been widely associated with computer science (CS). Library and Information Studies (LIS) youth services faculty participating in the American Library Association (ALA) Libraries Ready to Code (RtC) initiative in the United States (U.S.) identified CT as a critical literacy for youth (Martin, 2017), preparing them to master primary and secondary school STEM (Science, Technology, Engineering, Math) standards (Yadav, Hong, and Stephenson, 2016) and to guarantee youth have skills essential to future employment and civic participation. CT literacy includes strategies and skills from problem solving, critical thinking, debugging, creativity, and collaboration. All of these skills are already in demand in many sectors of the workforce and are anticipated to be essential for the future workforce when today's students graduate. In the U.S., however, access to programs that build CS and CT literacy is unequally distributed both because programs are unavailable, and where they are available youth are not guaranteed to pursue the opportunity (Google Inc. & Gallup, 2015). To address these gaps, it is especially important that libraries, whose missions focus on equity, diversity, and inclusion, provide CT programs for youth with less access or exposure to such programs. To ensure the youth in their communities have opportunities to develop CT literacy, library staff must themselves have opportunities to build skills and confidence to incorporate CT into the programs they design with and for youth.

In the U.S., corporate, professional, and government entities, including College Board; the National Academies of Science, Engineering, and Medicine's Computer Science and Telecommunications Board; the National Science Foundation; Microsoft Research; and Google have been developing CT-specific initiatives to be implemented into school curriculum (Wing 2010; Grover and Pea, 2013). The current iteration of International Society for Technology in Education (ISTE) Standards for Students (2019a) and International Society for Technology in Education (ISTE) Standards for Educators (2019b) identifies CT as one of the six major standards students should master during their primary and secondary school experience, positing "students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions." The American Association for School Librarians (AASL, 2018a) emphasizes the need for schools to embed the ISTE standards in curriculum, including the development of CT skills.

Currently a disconnect exists between CT as defined by CS and CT in the context of LIS (e.g., CT as a literacy) creating conflict within both communities as to what the library contribution should be in this space. While CT in CS focuses on skills required for computing, CT literacy transcends the CS arena, as the strategies and skills transfer to multiple curricular areas, college readiness, career readiness, and everyday life issues. LIS, while acknowledging the necessity for youth to be STEM proficient, focuses on communities holistically, recognizing people need problem solving skills applicable to multiple arenas, and that such skills should be taught both inside and outside the context of computing. Youth need access to formal and informal learning opportunities allowing them to develop CT literacy in a wider context (Sykora, 2014; Smith, 2016; Braun & Visser, 2017). Public and school librarians have provided resources and programming to encourage lifelong, formal, and informal learning with an emphasis on facilitating patron development of multiple literacies (IFLA, 2006; IFLA, 2018), thus making libraries an ideal space to facilitate CT literacy development. Moreover, the Young Adult

Library Services Association (2017), the American Association of School Librarians (2018b), and the Association for Library Services to Children (2015), in their recently revised and respective research agenda, standards, and competencies, address the need for youth services librarians to provide youth with formal and informal learning spaces, to address curricular and personal needs of youth patrons, to provide equity of access to resources and services, and to prepare youth to be lifelong learners.

While CT opportunity is widely endorsed by the education community and the resulting literacy desired by employers, current initiatives and investments made indicate the focus has been on in-service professional development. This approach is important but incomplete, leaving new librarians ill-prepared to meet the needs of the youth and the communities they will ultimately live and work in. For example, previously funded Institute of Museum and Library Services (IMLS) projects exploring CT and youth have typically focused on coding and/or training the trainer models, revealing a continued gap in research and materials to prepare librarians with skills necessary to design and implement programs through which youth develop CT literacy.

Arizona State University's Center for Gender Equity in Science & University of Michigan's School of Information provide public library staff with professional development and training to teach CT skills. The North Dakota State Library project is also working with current library staff and focusing on specific coding programs to promote CT skills. These two examples and existing LIS research indicate that in-service librarians and library staff are being trained to integrate CT into library programming, and specific libraries are experimenting with developing CT programs for youth. Absent, however, are projects for pre-service librarians through their formal graduate programs, aside from Phase II of the Libraries Ready to Code (RtC) initiative. Further, a scan of the National Science Foundation, which has heavily invested in CS education, shows thousands of CT-focused funded grants with emphasis on CS and/or formal education but not youth services librarians.

With 500,000 current job openings in the field of CS in the U.S., all 115,000 of the nation's school and public libraries are crucial community partners to guarantee youth have skills essential to future employment and civic participation. Beyond a direct CS degree, CT and knowledge of CS principles is critical to accessing workforce opportunities. One third of jobs in 2020 will require skills that are not commonly taught today, more than 50% of jobs in 2020 that will require an "engineering mindset" (World Economic Forum, 2019), and digital-based, middle-skilled jobs are growing at 150% compared to other kinds of jobs (Burning Glass, 2015). To discover how libraries support CS, coding, and CT literacy acquisition by youth, ALA initiated the RtC initiative, sponsored by Google. Launched in 2016, Phase I of the initiative produced a report based on an environmental scan of the current status of computer programming activities in U.S. public and school libraries. Results from Phase I concluded youth librarians often conflate coding with CT as well as doubt their abilities to integrate CT into curricula and programming (Braun & Visser, 2017). From these findings, a second phase of RtC was designed with the goal of bringing CT into the current LIS youth services curriculum at several LIS programs in the U.S.

RtC Phase II featured a cohort of six LIS faculty members who collaboratively revised their LIS youth services technology courses for pre-service librarians, integrating CT activities. The collaborative, iterative process identified challenges of integrating CT into LIS youth focused courses and further refined strategies for building the capacity and confidence of librarians identified in Phase I.

Approach

Phase II participants, faculty fellows, selected youth services technology courses to incorporate concepts identified in RtC Phase I as requisite for rich CT learning experiences through libraries, including coding within the context of CT. Faculty fellows collaboratively redesigned their courses during the spring and summer 2017 semesters and taught the revised courses in the Fall 2017 semester. Data were collected from the faculty fellows and 149 students who volunteered as participants. In alignment with existing research, faculty fellows concur that LIS educators have a responsibility to develop curriculum preparing pre-service librarians to integrate CT into library programs, as the library is an ideal location for youth to explore CT literacy.

To create a dialogue for change within youth librarianship and in the pedagogy of CT, the faculty fellows piloted CT activities in their redesigned courses with the following goals:

- Contribute to changing perceptions of who can code and who can lead coding activities
- Increase exposure to coding and computational thinking
- Generate interest in coding and computational thinking
- Teach pre-service librarians how to frame computational thinking beyond computer science

The course redesigns consisted of four main activities: reading about CT, defining CT and discussing the relevance to library youth services, creating model syllabi for LIS faculty not in the cohort, and integrating a hands-on coding activity to demonstrate the connection between computational thinking and computer coding. The following course projects exemplify the variety of approaches faculty fellows used during the redesign process.

Example 1: Computational Thinking Flowchart and Reflection Project

Forty-three graduate-level students earning their school librarian certification (primarily pre-service school librarians and a few in-service librarians) piloted the Computational Thinking Flowchart and Reflection Project in the Fall 2017 semester in an instructional technology course specific to school libraries. After two modules including two lectures, two weeks of course readings, and one online, asynchronous discussion, students created an online flowchart illustrating the application of CT as a problem-solving process to a self-selected problem. The problems could be teaching-specific (how to teach certain concepts in math, English, etc.) or personal (selecting a vacation location, training for a half-marathon, developing a plan for cleaning the house, etc.). For each CT concept (decomposition, pattern recognition, algorithm design, and abstraction), students explained the specific actions they would take to complete the action and then wrote a rationale explaining how the actions were indicative of each concept. Although students were typically able to successfully delineate the four steps required to solve their problems, challenges arose with them clearly articulating how each step exemplified each CT concept.

Prior to the two modules on CT, students indicated they were unfamiliar with the phrase "computational thinking." After listening to the lectures and completing the readings and project, a few students stated they had used the process but were unaware it had a name. This assignment emphasized a dialogue for change not only in the way the graduate-level students approached problem-solving but also in how they will teach their future students (ages 5 years

through 18 years) to solve problems in myriad contexts outside the realm of coding and computer science. Students self-selecting their problems instead of responding to imposed queries granted students the opportunity to work within a context specific to each student's own life, thereby broadening the perspective of computational thinking as a problem-solving process.

Example 2: Computational Thinking as Iterative Process

CT was integrated into a Multimedia Production course with eighteen graduate students. Several readings and short videos were assigned as homework. When students arrived to class they participated in an interactive lecture that included writing exercises where students attempted to define CT. They were first challenged to write their own definition of CT followed by a think-pair-share activity where they attempted to construct a library-centric definition of CT. The students then collaboratively developed a course-specific definition of CT and engaged in a conversation about how libraries could integrate the concept.

To mitigate challenges CS-centric definitions of CT present in the library context, CT was not treated as a single module. Rather, CT was introduced as an iterative process to be used with throughout the course. For example, when tasked with creating a short digital video, decomposition was used to break the project down into several small pieces and processes such as audio recording, programming sound loops, building a soundtrack, recording voice overs, capturing ambient sounds, and creating sound effects. Once completed each project was then shared with the class in a round of peer-to-peer feedback. Students used a rubric to discover patterns between the early drafts of projects.

During peer-to-peer feedback students identified several patterns (early mistakes) in their work such as "hissing" or "clipping" in recordings, scenes needing to cut to keep their narrative flowing, and voiceover levels needing to be amplified over sound effects and soundtracks. The process of peer review was linked to with pattern recognition in CT.

By participating in CT as a process, students were able to internalize the core aspects of decomposition, pattern recognition, abstraction, and algorithm design. Through frequent peer review students formed strong bonds and became invested in each other's work. By engaging in an iterative process CT became a sustained practice and ended up being a major course theme.

Findings

The RtC Phase II evaluation identified multiple challenges and opportunities in embedding CT in LIS youth-focused technology courses. Faculty fellows entered the project in agreement that libraries are places for youth to develop CT skills and that LIS programs should better prepare youth librarians for this role. Participation in the project further cemented this perspective. Faculty grappled with how to "do" CT, a challenge which stemmed from multiple CT definitions and the lack of a specific one that fit the LIS and library context. Similarly, students were not experienced with CT and struggled with understanding both why they should incorporate CT into library programs and how to effectively do so. While this paper does not focus on student experiences, it is useful to include them to infer the effectiveness of the course redesigns.

Because there are several definitions of CT in CS, CS education, and math education, both faculty fellows and students had a difficult time defining CT, which lead to challenges in course redesign and student assignments or projects. Faculty reported having to spend far more time than had been planned to discuss the meaning and distinctions of CT within the context of LIS. However, these common definitions include more well-known instructional strategies, such as critical thinking, which encouraged faculty and students to see a role for libraries in CT work. Through a collaborative and iterative process, faculty, and subsequently students, aligned CT principles to LIS and library professional values and objectives, including ensuring library programs are equitable and inclusive of diverse voices. This alignment resulted in reframing CT skills as CT literacy.

Related to this, within the redesigned courses, students did not necessarily make the connections between CT and subsequent coding activities but perceived them as separate activities. But, after reviewing the initial course evaluations, faculty redesigned their activities a second time to reinforce the connections and to spend more time helping students understand CT as a concrete set of skills rather than an abstract idea. Student projects improved with each iteration of the course. At the conclusion of the semester, many students referred to CT literacy as important to integrate into the library profession and indicted increased confidence for being able to design CT programs for youth.

Implications for additional work stem from only involving six LIS programs in the project. While some dissemination occurred through conference presentations and articles, redesigned syllabi have not been broadly shared with other LIS programs and would need to be shared through collaborative workshops or similar peer learning activities, supporting the finding that embracing CT in the LIS context is an iterative process. While professional development opportunities exist for faculty in graduate teaching programs, opportunities for LIS faculty are limited. Incorporating CT into professional development programs is another area for future attention. Findings from the subsequent Phase III of the RtC initiative also call out the need for pre-service librarians to have opportunity in their courses to develop requisite skills and confidence to provide high-quality CT programs for children and youth.

Conclusion

In alignment with existing research, faculty fellows agreed that LIS educators have a responsibility to use curricula as a dialogue for change, thus developing curriculum preparing pre-service librarians and library practitioners to develop and integrate CT into library programs, as the library is an ideal location for youth to explore CT concepts. Preparing librarians to facilitate CT programs is especially important to ensure equitable opportunity for diverse youth and aligns with core professional values of equity, diversity, and inclusion. However, integrating CT concepts into LIS curricula will require an ongoing and concerted effort. Students who completed the redesigned courses noted the importance of librarians serving as facilitators for youth CT literacy development, indicated a greater comprehension of CT and related concepts after completing the courses, and expressed intent to integrate CT into library programming (Martin, 2017).

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