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WySLICE - Integrating Computer Science throughout Existing K-12 Core Disciplinary Areas

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Mike also has over a decade of industry and research experience – mostly revolving around the semiconductor and bioinformatics industries – with specific experience at Texas Instruments, Intel, and Cincinnati Children's Hospital Medical Center. In addition to his industry experience, Mike spent two years, while completing his Ph.D., as a National Science Foundation GK-12 fellow – teaching and bringing real-world STEM applications in two urban high schools. Since then, he has worked with university faculty to promote and extend K20 STEM outreach in Ohio, Oregon, Texas, and Wyoming. He has authored peer-reviewed articles and papers, presented at national and international conferences, and taught undergraduate/graduate courses in Computer Security, Data Mining, VLSI and pedagogy in STEM.

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Dr. Andrea C. Burrows is a Professor in the School of Teacher Education and Associate Dean of Undergraduate Programs at the University of Wyoming (UW).She received her doctorate degree from the University of Cincinnati in 2011.She was awarded the UW CoEd Early Career Fellowship (2013), UW CoEd Faculty Award for Outstanding Research and Scholarship (2015), UW CoEd Faculty Award for Outstanding Service to the Education Profession (2016), UW CoEd Honored Fall Convocation Faculty (2017), and UW CoEd Faculty Award for Outstanding Research and Scholarship (2019).Since beginning at UW, Burrows has written, implemented, or evaluated over 50 unique grants. She has been the Program Director for GenCyber as well as PI of NSF grants for STEM and CS work. The core of her research agenda is to deepen science, mathematics, engineering, and technology (STEM) partnership involvement and understanding through STEM interdisciplinary integration with in-service teacher professional development (PD) and pre-service teacher coursework. Her research agenda is composed of a unified STEM education partnership structure and connects educational research to real-world practices.Burrows' many publications appear in leading journals.She is the Co-Editor ofCITE-Journal Science(www.citejournal.org). She is active and presents in several organizations such as AERA, ASEE, ASTE, NSTA, and SITE.Before beginning her work in higher education, she taught secondary school science for 12 years in Florida and Virginia (USA).

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Abstract

This project assembles a network improvement community comprised of partners from the University of Wyoming, community colleges, Wyoming school districts, the Wyoming Library System, the Wyoming Department of Education, and local software development firms. The community meets once monthly over the duration of the project to collaborate stakeholder agendas for meeting the project goals. The community enlists K-8 teachers from across the state to experience professional development (PD) and collaborate on integrating computer science into their instruction of STEM and social science topics. The project is producing units for teachers, who are implementing these units with support from master teachers and educational scholars. The community serves as a forum for teachers to debrief and learn from each other about ways to improve their instruction and design of the curricular units. Libraries in the state system act as partners for dissemination to rural areas of the innovative instructional approaches. As a result, in addition to increased knowledge, there was a significant improvement in participants' confidence with integrating CS into their practice as well as their beliefs that they can affect student learning outcomes in computer science.

Introduction

As an educational community and especially in science and engineering education, we understand that computer science is a channel to enter high demand STEM occupations (Bureau of Labor Statistics US Department of Labor, 2018). Specifically, in 2018, computer and information technology occupations are projected to grow 13% over the next eight years (Bureau of Labor Statistics US Department of Labor, 2018). However, for teachers emerging into the computer coding and computer modeling realms, computing skills are best served if they are utilized in conjunction with, or integrated, with existing coursework for teachers to embrace and use the skills (Burrows, DiPompeo, Myers, Hickox, Borowczak, & French, et al., 2016). Thus, although the skill of coding is an important one, it is not the sole means of providing computer science and computational thinking skills to K-8 administrators, teachers, and/or students. Other prominent researchers agree that teaching coding as an elitist endeavor, instead of as a skill or an experience, is not in K-12 students' best interest (Sengupta, Dickes, & Farris, 2018; Wilensky & Papert, 2010).

The WySLICE team concurs that an integrated computer science approach is vital for our rural state, and this region requires an integrated, rather than a stand-alone approach. In work by

Sengupta, Dickes, & Farris (2018), based on an NSF Career Award, provides pedagogical suggestions that the WySLICE team took to heart in designing and implementing a PD for K-8 administrators, teachers, and librarians. Following each of their suggestions, the team's PD approach (e.g. mission) is briefly described here. The PI team uses the proposed pedagogical guidelines for sustaining computer science aspects in K-12 classrooms (Sengupta, Dickes, & Farris, 2018).

1. Reframing programming and coding as 'modeling' as the design of mathematical units of measurement of change over time, for the K-12 science classroom;
2. Trans-disciplinary representational and epistemic practices such as design and modeling can help us support continuity in learning experiences across disciplines;
3. The importance of embodied modeling and non-computational materials as representational and cognitive amplifications of computational code;
4. The role of disciplinarily grounded, normative instructional approaches (e.g., socio-mathematical norms) in refining computational modeling;
5. Reframing coding and modeling as designing for an authentic audience;
6. The importance of using both visual and text-based programming languages for longer-term curricular integration (p. 29-30);

Literature Review

An NSF 'Researcher Practitioner Partnership - RPP' must showcase strong partnerships, and this is a challenging and purposeful task. As such, the WySLICE team relies on the work of the Research + Practice Collaboratory (researchandpractice.org) and the extensive work of the PI-Team's Burrows and Borowczak.

The "...educational research needs more active involvement of STEM educators, across all levels of the system and at all stages of research" (researchandpractice.org/whyrp/). Additionally, the PI team embraces the "Networked Improvement Communities (NICs) that bring together educators and researchers in multiple settings (for example, multiple districts, schools, or universities) to foster continuous refinement and improvement. Similar to design-based partnerships, these networks collaborate around shared problems of practice, and they develop, test, and refine initiatives. As opposed to design-based research partnerships, which tailor research efforts to particular settings, NICs involve similar research efforts across multiple settings" (Scher, McCowan, & Castaldo-Walsh, 2018, p. 10).

WySLICE also utilizes Pea and Collins' (2008) concept of the fourth wave of science education reform which "involves the emergence of a systemic approach to designing learning environments for advancing coherent understanding of science subject matter by learners." The innovative approach of integrated computer science instruction through K-8 student exploration and creation focused pedagogy, fostered by K-8 administrators, teachers, and librarians is an extension of prior work related to K-16 students

This lead the researchers to focus on four overarching research questions for the WySLICE project -

RQ1 What are WySLICE K-8 teacher perceptions of computer science before and after the integrated approach of computer science in Booting Up Computer Science in WySLICE?

RQ2 What is baseline K-8 teacher content knowledge of computer science before and after the integrated approach of computer science in WySLICE?

RQ3 How do K-8 teachers and librarians in differing content areas use the integrated approach of WySLICE after the PD and support?

RQ4 How do the Wyoming State Libraries and University of Wyoming endorsements and micro-credentials impact the sustainability of integrated computer science approaches in K-8 classrooms around Wyoming?

Implementation

In the midst of the 2020 pandemic the WySLICE team recruited a diverse educator participant pool from around the state of Wyoming. Ultimately, 24 educators, spanning traditional and libraries' educational domains applied and participated in the year-long PD engagement. The educators, made up of seven (7) librarians and 17 classroom teachers, self-selected to participate in a week-long summer experience that was supplemented with academic-year supports.

The educators participating in this activity provided researchers invaluable mixed-methods data, insights and feedback which developed future CS engagements. Ultimately, the 24 educator participants provided group leaders with over 49 lesson plans and another 30 implementation plans.

Methods

In order to address the research questions the researchers employed a mixed methods study to collect, and address open questions within the field of CS education. A formative evaluation of the WySLICE project, conducted annually by an external evaluator, focuses on evaluating specific project activities for continuous improvement, while a summative evaluation explores project outcomes. Preliminary reports will provide specific feedback from the PD and is intended to formatively support the project.

WySLICE, a five-day PD, was first provided to educators from July 6 - July 10, 2020.The five-day schedule included:

- Day 1 - What is computer science?
- Day 2 - What are computer science and the WyCS Standards?
- Day 3 - What are computer science/standards and integrated approaches?
- Day 4 - Deep Dive with Activities

- Day 5 - Review and Project (Lesson Plan, Activity + Outreach Demonstration) Presentations

Participants

A total of 24 educators participated in the week-long WySLICE PD in the summer 2020. The participants were K-8 educators and librarians. All participants completed a pre-survey administered before the start of the program and a post-survey administered the final day of the training. At the start of the PD participants were asked about their interest and availability to participate in a focus group discussion. Of the 17 participants who indicated that they would participate in a focus group, eight participants were selected at random with a goal of including a representative sample of roles. In all, three teachers, two librarians, and one master teacher participated in a virtual focus group discussion in summer of 2020.

Instruments

Participants were asked to complete a modified version of the 25-item Science Teaching Efficacy Belief Instrument (STEBI) developed by Riggs and Enochs (1990). The instrument was originally designed to assess the levels of teachers' self-confidence in teaching science topics, as well as their general beliefs about whether teachers have an influence on student learning outcomes. The instrument consists of two scales, the Personal Science Teaching Efficacy Belief scale, WySLICE Year 1 PD Preliminary Survey, and the Science Teaching Outcome Expectancy scale and uses a 5-point Likert scale with response categories: ”strongly agree,” ”agree,” ”uncertain,” ”disagree,” and ”strongly disagree.” For WySLICE, the questions were modified to reflect efficacy belief and outcome expectancy for teaching computer science, instead of science in general (e.g.,“I understand Computer Science concepts well enough to be effective in teaching them,” for teaching efficacy, and “Students' achievement in Computer Science is directly related to their teacher's effectiveness in science teaching,” for outcome expectancy).

An intrascale reliability analysis found acceptable reliabilities (13-item Personal Science Teaching Efficacy Belief scale α = .91; 12-item Science Teaching Outcome Expectancy scale α = .77). As such, a summation score was created for each scale and was those score are used as the primary analyses. The resultant summation scores for the scales had possible ranges of 13 to 65 for efficacy and 12 to 60 for outcome expectancy. Finally, a higher summation scores indicates higher levels of teaching self-efficacy and outcome expectancy.

A set of four questions was designed to test participants' knowledge of computer science before and after attending the PD training as well as their awareness of WySLICE's computer science standards. Participants' pre- and post- survey responses to one of the four questions were analyzed - namely, ”Which of the following best describes Computer Science?”

Differences in self-efficacy and outcome expectancy pre- and post-PD training were determined by analyzing the results of a paired samples t-test comparing participants' pre- and post- survey scores for the 21 of 24 participants completing both the pre and post survey - the three of the 24 participants who did not complete the post-survey are excluded from the results..

Results

In order to understand if WySLICE participants understood the definition of computer science, they were asked, ”Which of the following best describes Computer Science?” with the correct selection having some reference to ”problem solving.” 95% (n = 20) of participants made the correct selection at the end of PD, compared to 81% (n = 17) at the beginning of the PD. Additionally, all four participants who made an incorrect selection in the pre-survey made the correct selection in the post-survey.

Overall, teachers and librarians reported that their content knowledge in computer science increased after attending the PD. For context, several of the participants indicated that they had little to no computer science knowledge at the beginning of the training and that they were more knowledgeable afterward. Participants also reported that the PD enabled them to better understand that teaching CS involves more than coding and that problem-solving and helping students think outside the box were also important elements. **Participants also noted that they better understood how CS concepts could be integrated into almost any kind of instruction for all students even without computer access**. They felt that the WySLICE instructors were effective in helping them understand how CS could be incorporated across disciplines such as reading, math, or social studies. One participant stated, *”The takeaway would be that they really drilled in that, whatever your space is, how to take that and use it the way you can use it. No, I don’t need 30 min in the computer lab, no I don’t need 30 min after school, I can take what I’ve learned and use it in the time that I have to use it.”*

During the focus groups participants also discussed their strategies for implementing CS within the classroom and expressed excitement in sharing their increased content knowledge with their colleagues. Librarian-participants, in particular, viewed their role as being a CS leader with teachers. The librarians expressed a goal of being able to provide CS instructional leadership within their schools while teachers shared creative ways they would share their new CS knowledge with colleagues (e.g., using unplugged activities in holiday parties).

Discussion

The results indicate that there was a significant improvement in participants’ self efficacy for teaching computer science, as well as significant improvement in beliefs that teachers can affect students’ learning outcomes in computer science.

The week-long PD for teachers and librarians was largely viewed as successfully increasing participants’ knowledge and confidence with implementing CS in their practice.From the focus group, participants also self-reported that their knowledge had increased and provided numerous examples of how they intended to implement their newfound skills and share their knowledge with colleagues.

In addition to increased knowledge, there was a significant improvement in participants’ confidence with integrating CS into their practice as well as their beliefs that they can affect student learning outcomes in computer science. These findings were also consistent with findings from the focus group as participants noted that though they still felt like they needed to continue to develop their skills, they felt more confident overall. Finally, the week-long PD, the bank of lesson plans that teachers have created and continue to update (http://uwyo.edu/wyslice), and access to the trainers were viewed as valuable resources to support teachers and librarians.

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References

[1] U.S.Census Bureau. National and state population estimates. URL `https://www.census.gov/newsroom/press-kits/2017/estimates-demographics.html`. Retrieved from.

[2] A.C. Burrows. Secondary teacher and university partnerships: Does being in a partnership create teacher partners?, .

[3] A. Burrows, G. Wickizer, H. Meyer, and M. Borowczak. Enhancing pedagogy with context and partnerships: Science in hand. In *Problems of Education in the 21st Century*, page 54. .

[4] A.C. Burrows. Partnerships: A systemic study of two professional developments with university faculty and k-12 teachers of science, technology, engineering, and mathematics. *Problems of Education in the 21st Century*, 65(1):28–38, .

[5] A.C. Burrows, M. DiPompeo, A. Myers, R. Hickox, M. Borowczak, D. French, and A. Schwortz. Authentic science experiences: Pre-collegiate science teachers' successes and challenges during professional development. *Problems of Education in the 21st Century*, 70:59–73, .

[6] A. Burrows, M. Lockwood, M. Borowczak, E. Janak, and B. Barber. Integrated stem: Focus on informal education and community collaboration through engineering. *Education Sciences*, 8(1):4, .

[7] U. Wilensky and S. Papert. Restructurations: Reformulations of knowledge disciplines through new representational forms. *Constructionism*.

[8] U. Wilensky, C.E. Brady, and M.S. Horn. Fostering computational literacy in science classrooms. *Communications of the ACM*, 57(8):24–28.

[9] P. Sengupta, A. Dickes, A.V. Farris, A. Karan, D. Martin, and M. Wright. Programming in k-12 science classrooms. *Communications of the ACM*, 58(11):33–35, .

[10] P. Sengupta, A. Dickes, and A.V. Farris. Toward a phenomenology of computational thinking in k-12 stem. In M.S. Khine, editor, *Computational Thinking in STEM Discipline: Foundations and Research Highlights*. Springer, .

[11] L. Scher, R. McCowan, and C. Castaldo-Walsh. Regional educational laboratory researcher-practitioner partnerships: Documenting the research alliance experience.

[12] Iris M. Riggs and Larry G. Enochs. Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education*, 74(6):625–637, 1990. doi: https://doi.org/10.1002/sce.3730740605. URL `https://onlinelibrary.wiley.com/doi/abs/10.1002/sce.3730740605`.