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Preservice Teacher Computer Science Preparation: A Case Study of an Undergraduate Computer Education Licensure Program

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This study presents the design of a Computer Education Licensure (CEL) program based on a situated learning theory framework. The study captures instructors' design considerations while designing the courses in the CEL program based on this theoretical framework. The study also captures preservice teachers and alumni perceptions regarding the value of courses that were informed by this framework. Additionally, the study presents longitudinal data from four preservice teachers who pursued their license from the CEL program, and later moved into teaching positions. Longitudinal interview data began capturing perceptions and experiences during participants' student teaching year in the CEL program and continued into their first and second years of inservice teaching. Based on the analysis of data from these sources, we conclude that situated learning characteristics were present in all courses of the CEL program. The use of three specific situated learning characteristics (authentic contexts, authentic activities, and reflection) were emphasized by all instructors as being major considerations in course design. Despite this, teachers only emphasized the value of having authentic contexts and authentic activities. Suggestions for similar computer science licensure programs are recommended based on these findings.

INTRODUCTION

Computer science has been suggested as a basic skill for all K-12 students, and no longer seen as an optional elective. As stated by President Obama in 2016, "Our economy is rapidly shifting, and both educators and business leaders are increasingly recognizing that computer science (CS) is a 'new basic' skill necessary for economic opportunity and social mobility" (The White House, 2016). In addition to being considered as a basic skill, industry leaders have increased their demand for future employees to possess computer science related skills. The Bureau of Labor Statistics has projected that from 2016 to 2026 there will be a 13 percent growth in computer and information technology systems, which is faster than average across all occupations. Based on this outlook, it is imperative that today's K-12 students are given the opportunity to build a foundation of computational science skills so they are better prepared for future opportunities (Grover & Pea, 2013; Lee, 2015; Pellegrino & Hilton, 2013; Wilson et al., 2010).

Many states are trying to increase computer science education opportunities for K-12 students. As of 2016, there were seven states that had adopted K-12 CS standards, while eight additional states were in progress on standards (Stanton et al., 2017). As of October 2017, 10 states had K-12 CS standards, and an additional 10 were working on developing standards (Patel, 2017). Furthermore, four states require all high schools to offer computer science (Texas, Arkansas, Virginia, West Virginia) (Stanton et al., 2017).

However, if computer science were to be offered in every school across every state, there would not currently be enough computer science teachers to meet this demand. There have been many initiatives and professional development offerings designed around educating middle school and high school computer science teachers (Menekse, 2015). However, most of the plans for preparing or certifying computer science teachers draw on existing teachers, often math or science, which are already high demand areas (Goode, 2007; Lang et al., 2013). Some have suggested that to meet this demand for more computer science teachers, we will need to look towards preservice teacher programs (Lang et al., 2013; Southern Regional Education Board, 2016).

Preservice Teacher Licensure for Computer Science Education in the US

One of the ways institutions are responding to this need is through different courses or certification programs. According to Higher Education Act

Title II data (2016), only 75 preservice teachers graduated from universities equipped to teach computer science, as opposed to 12,528 teachers prepared in mathematics and 11,917 teachers prepared in the sciences (across general science, biology, chemistry, physics, and earth science). The question then becomes, how can we prepare more computer science teachers, and what are the best methods to achieve this? Other STEM fields such as mathematics education (e.g., Bagley, 1933; Monk, 1994) and science education (e.g., DeBoer, 1991; Klopfer, 1969) have investigated this topic/question for the past century.

There is a dearth of information on programs preparing preservice teachers to teach computer science (Phillips & Stephenson, 2013; Yadav, Hong, & Stephenson, 2016). Additionally, there is a significant amount of confusion around the requirements necessary to become a qualified teacher of computer science (Ericson et al., 2007; Gal-Ezer & Stephenson, 2010; Gal-Ezer et al., 2014; Phillips & Stephenson, 2013; Seehorn et al., 2011; Simard et al., 2010; Wilson et al., 2010). There are also multiple states that lack designated requirements for becoming a computer science educator (Gal-Ezer & Stephenson, 2010; Lang et al., 2013). Overall, Lang et al. (2013) reported:

> It is difficult to draw broad conclusions about the certification of Computer Science teachers in the country beyond the fact that it is not working. Each state has its own process, its own definition of Computer Science, and its own ideas about where it fits in a young person's educational program (if at all) (p. v).

Organizations like the Computer Science Teacher Association (CSTA) have attempted to bring attention to this issue by publishing a series of reports and recommendations for computer educator licensure programs, but more work needs to be done to understand and address the complications of this field (Phillips & Stephenson, 2013). For over a decade, these reports have urged for defining standard competencies and creating certification programs for computer science educators (Gal-Ezer et al., 2014; Phillips & Stephenson, 2013; Tucker et al., 2003). The only current standards for computer science teachers are the Interational Society for Technology in Education (ISTE) Computer Science Educator standards that were developed in 2011 with the assistance of the Computer Science Teachers' Association. However, with so few programs currently preparing computer science preservice teachers, what is the best way to teach computer science to preservice teachers who are likely not to have had any prior knowledge of the topic?

Teacher Licensure for Computer Science Education in Indiana

The state of Indiana is one of 12 states that offer teacher licensure in computer science (Stanton et al., 2017). Within the state of Indiana, computer science teachers are required to have a license to teach computer science. This license is considered an add-on or supplemental license, meaning that a candidate must hold an Indiana teaching license in a core subject area to be recommended for the addition of this computer education license.

The computer education license can be at either the elementary (PreK-6) or secondary (5-12) level. Teachers with a secondary computer education license can teach basic computer applications courses, web design, and computer science courses (e.g., Computer Science Programming, Computer Science Databases, AP CS Principles, and AP Computer Science A). Those with an elementary computer education license are prepared to teach Indiana's newly approved Computer Science standards for K-8 students. The standards are based on the five core concepts: Computing Devices and Systems, Networking/Communication, Data/Information, Programs/Algorithms, and Impact/Culture. Within Indiana, only two universities currently offer this add-on licensure at the preservice level: Indiana University-Bloomington and Ball State. This descriptive case study sought to investigate the Computer Educator License (CEL) program at a large university in Indiana. The program utilized situated learning theory to guide the design of the program.

Theoretical Framework for CEL Course Design

The courses in the CEL program have been designed based on a situated learning theoretical framework (e.g., Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; McLellan, 1996). This framework has been previously used in other preservice teacher preparation programs to support the development of technology skills (e.g., Bell, Maeng, & Binns, 2013; Hur, Cullen, & Brush, 2010). Situated learning theory suggests learning should take place in authentic environments, rather than be distinct from the context where knowledge will be applied (Brown, Collins, & Duguid, 1989; Herrington & Oliver, 1995; McLellan, 1996; Young, 1993). Within situated learning theory, learning is a social, coparticipatory process that does not occur in isolation (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; McLellan, 1996). This is contrasted with traditional, formal learning environments where learning is separated from the authentic contexts where it will be applied (Brown, Collins, & Duguid, 1989; Herrington & Oliver, 1995). Overall, situated learning theory suggests that for learning to be effective, it must be situated within the context and culture of use (Brown, Collins, & Duguid, 1989; Herrington & Oliver, 1995; Young, 1993).

More specifically, utilizing a situated learning approach means preservice teachers must learn and practice in situations that are similar to the contexts they will find themselves after graduation (Bell, Maeng, & Binns, 2013; Hur, Cullen, & Brush, 2010). In other words, they must observe and participate in communities of practice, where the type of work they will be doing, is currently being done (Herrington & Oliver, 1995). In their 1995 analysis of situated learning literature, Herrington and Oliver discussed nine critical characteristics of situated learning, which were specifically implemented across the CEL courses. Based on their findings, situated learning environments:

1. "Provide authentic context that reflect the way the knowledge will be used in real-life;
2. Provide authentic activities;
3. Provide access to expert performances and the modeling of processes;
4. Provide multiple roles and perspectives;
5. Support collaborative construction of knowledge;
6. Provide coaching and scaffolding at critical times;
7. Promote reflection to enable abstractions to be formed;
8. Promote articulation to enable tacit knowledge to be made explicit;
9. Provide for integrated assessment of learning within the tasks" (p. 255).

The primary goal for designing the CEL courses based on this theoretical framework was to provide preservice teachers with authentic, collaborative, and reflective experiences to better prepare them for their future careers (e.g., Bell, Maeng, & Binns, 2013; Hur, Cullen, & Brush, 2010).

The Computer Education Licensure Program

The Computer Educator License (CEL) program described in this study is designed to meet the ISTE-CSE standards for accreditation purposes. Additionally, courses are designed to meet the ISTE standards for coaches and for educators, as well as the situated learning characteristics discussed above. Indiana teachers with a computer education license must be able to teach web design, graphic design, computer applications, and digital citizenship. Furthermore, teachers must pass the Pearson 013 test, which includes questions about networks, hardware and software, technology integration pedagogy questions, as well as web design, graphics, computer applications, and computer science. Overall, the CEL program is meant to train preservice teachers who will be qualified to: (1) Serve as a technology resource person, coordinator, or facilitator in local schools and school corporations; (2) Manage a school's technology resources, computer labs, and equipment; (3) Teach computing courses (computer applications, web design, computer programming) in Indiana secondary schools; and (4) Enhance marketability in the job market by demonstrating additional knowledge and experience related to technology integration in the classroom.

The CEL program consists of six courses (21 credit hours) with six credits being student teaching hours. For the last two years, each cohort has consisted of approximately 20 students representing both elementary and secondary levels, and with the large majority being female. Approximately 8-12 preservice teachers complete and graduate from the CEL program each year.

The sequence and content of coursework at the time of the study is as follows (Table 1):

Table 1
Computer Education Licensure Program
course names and content in 2012-2014

Course Title	Course Content
W210: Survey of Computer-Based Education	This course focused on introductory coding and programming skills using HTML, CSS, and robotics. Additionally, students participated in several small field experiences as well as host a STEM night at a local school at the end of the semester.
W220: Technical Issues in Computer-Based Education	This course focused on hardware, software, networking, and programming. This course covered PHP language, in order to provide students with a foundational understanding of coding.
W310: Integrating Technology in K-12 Classrooms	This course modeled how preservice teachers could teach computer science using Code.org's CS Principles curriculum. Additionally, there were required field experiences of 10-15 hours where students were asked to design and implement computer science-based lesson plans in a local K-12 classroom.
W435: Technology Leadership in K-12	This course focused on school-wide implementation of technology. Students were required to spend time shadowing a current technology leader at a local school. The topics of troubleshooting, professional development design, and technology budgeting/funding were also addressed.

Course Title	Course Content
W410: Practicum in Computer-Based Education	During the practicum experience, preservice teachers were asked to plan and implement two technology-based lessons over the course of the semester. There was a requirement for the preservice teachers to not only teach their students how to use technology, but also to integrate that technology in their primary license subject area in a meaningful way. Throughout the semester students also completed reflections and blog posts outlining their classroom progress and experiences.

Recruitment for the CEL program occurs multiple times throughout preservice teachers' first year in the School of Education. During freshman orientation, the CEL program is advertised at an information booth with robots and technology to capture preservice teachers' attention and provide basic information about the program. All freshmen in the School of Education are also required to take W200: Computers and Education. During the W200 course students are provided with additional informational videos and guest speakers to encourage them to consider enrolling in the program. All students in W200 complete the Hour of Code and participate in three weeks of computer science education activities. Through these recruitment strategies, the CEL program maintains a steady enrollment of preservice teachers.

The following section presents the research questions and the methods used to investigate the experiences of students who are currently enrolled in, or who have completed the CEL program, and the experiences of the instructors.

Research Questions

1. What characteristics did instructors consider as they designed the CEL program using a situated learning theory approach?
2. What situated learning theory characteristics did teachers perceive valuable as they completed the CEL program?

METHOD

Context and Participants

This study used a case study research design (Stake, 1995; 2003) to examine instructor course design considerations using a situated learning theory approach, and student perceptions of value for situated learning theory characteristics embedded throughout the CEL courses. The participants included in this study were: (1) current preservice CEL teachers (n=18); (2) alumni of the CEL program (n=9, 5 questionnaire participants, 4 longitudinal interview participants); and (3) CEL instructors (n=4). One CEL instructor was a faculty member and the CEL program director. The other three instructors were graduate students. All four instructors had previous K-12 experience, with one having previous computer science teaching experience in K-12 setting.

Data from the CEL instructors were captured through semi-structured interviews regarding their course design considerations. Data from the current preservice teachers and alumni were collected through an online questionnaire regarding their perceived value of the situated learning theory characteristics embedded in the CEL program.

The researchers also collected longitudinal data from four CEL program alumni through semi-structured interviews. The interviews captured their experiences in the CEL program, focusing on characteristics of situated learning theory. Longitudinal interviews were conducted at three points in time: (1) during the CEL program; (2) at the completion of the CEL program; and (3) after their second year of teaching. Finally, for a holistic understanding of the program, the researchers also conducted a document analysis of course syllabi to capture alignment with the ISTE standards, the situated learning characteristics described above, and the Pearson computer science licensure exam blueprint. The specific data sources used to answer each research question are outlined in the table below (Table 2).

Table 2

Data sources used to answer each research question

	Instructor Interview	Document Analysis	Preservice Teacher Questionnaire	Alumni Questionnaire	Alumni Longitudinal Interview
RQ1: Instructor course design considerations	X	X			
RQ2: Teacher perceptions of preparedness			X	X	X

Data Collection Instruments and Analysis Procedures

Data collection procedures began Fall 2012 and continued through Fall 2017 as shown below in Table 3. Interviews were conducted with the CEL instructors. Questionnaire data were collected from current CEL preservice teachers and CEL alumni teachers. A document analysis was conducted on six CEL course syllabi. Longitudinal interviews were also conducted with four preservice teachers who graduated and become inservice teachers.

Table 3
Data Sources and Semester Collected

	FA12	SU13	SP15	SU15	FA16	FA17	n
Preservice Questionnaire			X				18
Alumni Questionnaire			X				5
Document Analysis			X				6
Longitudinal Interview	X	X		X			4
Instructor Interview					X	X	4

Note. FA = Fall semester, SU = Summer semester, SP = Spring semester

Instructor interviews. A structured interview protocol was developed to address this study's first research question and gain an understanding of instructor considerations for course design. All four instructors (one being the CEL director) who taught in the CEL program were interviewed in person during Fall 2017. The interview protocol asked instructors to describe their course design considerations and provide specific examples of how these design considerations were enacted. All interviews were recorded and transcribed. Once transcribed, all interview transcriptions were sent to participants for member checking to improve validity (Merriam & Tisdell, 2015). Following transcription and member checking, a qualitative content analysis (Patton, 2002; White & Marsh, 2006) was conducted to address the study's first research question on instructor design practices. Quotes and examples from the interviews that aligned with the situated learning characteristics listed above were documented. These quotes were triangulated with data from the document analysis to determine what situated learning characteristics were used by instructors in the design of CEL courses. If the situated learning characteristics described by instructors were also described in course syllabi, they were documented.

Document analysis. A document analysis (Merriam & Tisdell, 2015) was conducted on the syllabi for the six courses of the CEL program to analyze their alignment with the Indiana secondary computer education standards, ISTE-A (administrators), ISTE-C (technology coaches), and ISTE-CSE (computer science educators), and the nine situated learning characteristics (Herrington & Oliver, 1995). Additionally, the Pearson computer science licensure exam blueprint and Indiana Computer Education standards were analyzed to look for alignment between the syllabi and the standards for Indiana computer education. The document analysis procedure began by collecting all current syllabi from instructors and adopted a system for coding (Merriam & Tisdell, 2015). This coding system was centered around three categories: (1) The ISTE standards; (2) The content of the Pearson licensure exam, and; (3) The situated learning characteristics. Two researchers read through all documents and noted all examples where course activities and assignments aligned with these categories. It was possible for one activity to align with multiple categories.

CEL teacher questionnaire. An online questionnaire was developed to capture teachers' perceived value of the situated learning theory characteristics embedded in the CEL program, and capture their perceptions of how this approach prepared them for their future classrooms. Two researchers constructed an initial draft of the questionnaire after interviewing two former CEL instructors. Once a draft of the questionnaire was completed, the questionnaire was presented to the CEL director for approval. The researchers then pilot-tested (De Vaus, 2014) the questionnaire with two former instructors and three evaluation specialists. Through this process, adjustments were made such as reordering items, eliminating questions, and clarifying the wording of questions. For example, the term "student teaching" was replaced with "practicum" as it was suggested preservice teachers would be more familiar with that wording.

The finalized teacher questionnaire included nine questions related to teachers' perceptions of value of CEL course experiences, with three questions being contingent on if preservice teachers had completed their student teaching. The rest of the questionnaire addressed topics such as reasons for enrolling in the CEL program, expectations for the CEL program, satisfaction of their expectations, and experiences related to field experiences. Examples of the open-ended questions included "How did your practicum prepare you for the job market?" and "How do you feel about your technology-related educational abilities as a result of the CEL program?"

The questionnaire requests for preservice teachers were sent to their school and personal emails during Spring 2015. The questionnaire was sent to all current 34 preservice teachers and 18 responded (53%). Preservice teachers that had not yet completed their student teaching did not answer questions related to student teaching experiences.

In addition, the same questionnaire form was used to capture information on CEL alumni's experiences. All questionnaire requests were sent to alumni's school emails as well as personal emails during Spring 2015. Out of the total 19 alumni, five completed the survey (26%).

Qualitative content analysis procedures (Patton, 2002; White & Marsh, 2006) were used to analyze questionnaire responses to address the second research question on teachers' perceptions of the CEL program. One researcher began the content analysis procedure by reading through responses to each of the nine open-ended questionnaire questions. Using memoing (Miles & Huberman, 1984), the researcher took notes on potential emergent themes (Stemler, 2001) that aligned with the study's second research question. The use of memoing allowed the researcher to work towards the extraction of emergent themes while also serving to better organize the analysis process (Miles & Huberman, 1984).

Two researchers then met together to review and discuss all potential emergent themes that had been identified by the first researcher. During this discussion, themes were consolidated where overlap existed. For example, the themes of perceived value based on field experiences, based on real-world experiences, and based on student teaching experiences, were combined into a single theme of perceived value based on authentic context and authentic activities.

Once the emergent themes had been finalized (Table 4), one researcher again read through all questionnaire responses to categorize each response within the final list of emergent themes. These emergent themes were also used for the categorization of the transcription data from the longitudinal interviews discussed below.

Table 4
Emergent themes of situated learning characteristics that preservice teachers perceived valuable

Theme Name	Definition	Example
Authentic context and authentic activities	Teachers reported valuing the situated learning characteristics of authentic contexts and authentic activities. Typically these two characteristics were described together, as a result of the field experiences preservice teachers participated in during the CEL program.	"I was exposed to a variety of school settings, learning environments (formal/informal), and age groups (5-15). I was able to practice different strategies and methods with different types of technologies and find my own preferences and style" (Alumni Questionnaire, 2015).
Computer Science Pedagogy	Teachers reported a desire for more authentic contexts and authentic activities specifically related to computer science pedagogy.	"While I have learned a good deal about educational technologies I don't feel like I am prepared to teach a computer course" (Preservice Teacher Questionnaire, 2015).

Longitudinal alumni interviews. Longitudinal interviews were conducted with four alumni CEL teachers to capture their perceptions of the CEL program, and their post-program experiences in their current K-12 classrooms. A semi-structured interview protocol was used that included 12 questions. The same interview protocol was used in all three interviews, and follow-up probes were used based on the time the interview took place (i.e., first, second, or third round), as well as the responses that were provided. The longitudinal interviews were conducted three times over a 3-year period. Once at the completion of the CEL coursework (Fall 2012), a second time after student teaching (Summer 2013), and a third time after two years of in-service teaching (Summer 2015). All participants began as preservice teachers in the CEL program and ended as inservice teachers. Interviews were conducted through Skype. All interviews were recorded and transcribed. Once transcribed, all transcriptions were sent to participants for member checking to improve validity (Merriam & Tisdell, 2015). Transcription data were analyzed to find quotes that aligned with the emergent themes described above in the questionnaire analysis.

Triangulation. Finally, triangulation occurred through the examination of emerging themes throughout these multiple data sources which allowed the researchers to establish and verify meaning across the multiple perspectives represented by participants (Stake, 1995; 2003).

Limitations. This results of this study were based on questionnaire and interview data, which were self-reported. Self-reported data can be prone to self-presentation bias (e.g., Kopcha & Sullivan, 2007). Additionally, the curricula of the CEL courses were continuously revised and updated. Therefore, the reported experiences of alumni may not reflect the latest developments of course content.

RESULTS

Results presented below are organized by research question. The first research question examined what characteristics the faculty considered as they designed CEL program courses using a situated learning theory approach. The second research question examined the teachers' perceived value of the situated learning theory approach during CEL program.

Research Question 1: What situated learning theory characteristics did instructors consider as they designed the computer education licensure program?

The analysis of interview data from the three CEL instructors and CEL director, as well as the course syllabi analysis, indicated that situated learning theory guided the design of all courses offered in the CEL program. While all nine situated learning characteristics were present in the syllabi analysis (Table 5), the characteristics that were most commonly reported by instructors as being primary considerations in their course design decisions were: (1) *Access to authentic contexts*; (2) *Access to authentic activities*; and (3) *Promotion of reflection.*

Table 5

Situated learning characteristics addressed in each CEL course

	W200	W210	W220	W310	W435	W410
Provide authentic contexts		X		X	X	X
Provide authentic activities	X	X	X	X	X	X
Provide access to expert performances	X	X	X	X	X	X
Provide multiple roles and perspectives				X	X	X
Support collaborative construction of knowledge	X	X	X	X	X	X

	W200	W210	W220	W310	W435	W410
Provide coaching and scaffolding	X	X	X	X	X	X
Promote reflection	X	X	X	X	X	X
Provide articulation for making tacit knowledge explicit		X		X	X	X
Provide integrated assessment		X		X		X

Access to Authentic Contexts and Activities

Data from instructor interviews and the syllabi analysis suggested that the situated learning characteristics of *access to authentic contexts* and *access to authentic activities* were often combined during CEL program experiences. *Authentic contexts* are seen as those that reflect "the way the knowledge will be used in real-life…[and] that invites exploration and allows for the natural complexity of the real world" (Herrington & Oliver, 1995, p. 256). *Authentic activities* are "ill-defined [where] students *find* as well as *solve* the problems" (Herrington & Oliver, 1995, p. 256). In the syllabi analysis, these two characteristics were often seen together, particularly during preservice teachers' field experiences. For example, in the W210 syllabus, an activity was listed where preservice teachers co-led a STEM night at a local elementary school. During the instructor interview, the instructor described that the preservice teachers were responsible for designing a computer science lesson that was delivered to groups of elementary students during the STEM night. This lesson plan creation was an example of an *authentic activity* where preservice teachers were faced with the ill-defined problem of designing a lesson to teach a complex computer science topic to elementary students. The delivery of the lesson during the STEM night was an example of an *authentic context* as the lessons were delivered to actual elementary students in a complex, real-world setting. From interview data, the director of the CEL program described how she considered *authentic contexts* and *authentic activities* during her general course design, as well as for this specific STEM night activity:

> From my work in teacher education, we know that our students seem to gain the most from the field – and they are constantly asking for more of these experiences. Therefore, we wanted to make sure we incorporated as many *authentic contexts* and

> *authentic activities* as possible, where students could apply the information they were learning in our classes in real-world settings. One great example that captures these ideas, is the STEM night activity in our W210 course. During this activity, we wanted our teachers to be exposed to both *authentic contexts* and *authentic activities* which is why we've worked towards building partnerships with local schools so these types of activities can be available.

A second example was found in W435 syllabus. Preservice teachers were required to spend a day shadowing a local technology leader. During instructor interviews, the instructor explained that this activity took place in an *authentic context* where the preservice teachers were with a local technology leader in their actual place of work (e.g., schools, meetings, district office, etc.). During the activity, preservice teachers were assigned *authentic activities* by the technology leader they were shadowing. For example, preservice teachers were asked to lead professional development meetings, provide technology coaching for teachers, and design technology support resources. These *authentic activities* provided preservice teachers with insight into the specific responsibilities of the technology leader role and offered opportunities to identify and solve ill-structured problems. Interview data from the CEL instructor who taught this course suggested these situated learning characteristics were central to the decision to incorporate this activity in W435:

> Our preservice teachers enter W435 with a very vague understanding of what technology coaches, technology coordinators, and other technology leaders actually do. The goal of the shadowing experience is to provide preservice teachers with *authentic contexts* and *authentic activities* where they can explore what this role looks like. I think this type of shadowing is such a valuable experience because not only are our preservice teachers learning from observation, but they are also being asked to participate in the technology leaders' daily responsibilities by providing support and training to local teachers.

Outside of these specific examples, providing students access to *authentic contexts* and *authentic activities* were also discussed more generally by all four instructors as being of central importance in course design. For example, one instructor stated:

> Providing our preservice teachers with as many *authentic contexts* and *authentic activities* is my number one priority. The

> more chances they get to see what's actually happening in real classrooms, the better able they will be to apply the concepts they're learning in class to their future careers. I am always looking for teachers to connect with, and opportunities to build partnerships with local schools so that our preservice teachers have as many real-world experiences as possible.

These ideas were echoed by all other instructors, who reported an intentional focus on designing learning experiences that offered *authentic contexts* and *authentic activities* to preservice teachers throughout the CEL program.

Promoting Reflection

The third major situated learning characteristic that was reported by all four instructors as being highly influential in course design was *promoting reflection*. This characteristic was also seen across all CEL courses in the syllabi analysis. Reflection is often seen as an active practice during which learners examine experiences, beliefs, and practices to form new knowledge and understanding (e.g., Dewey, 1933; Schön, 1987). The *promotion of reflection* most commonly appeared in CEL courses in the form of blogging. All CEL courses included blog reflections where preservice teachers were asked to write about the *authentic activities* and *authentic contexts* described above. These reflections were meant to help preservice teachers gain a better understanding of their experiences by considering their challenges, successes, and changes they might make moving forward. For example, in W310, preservice teachers designed and led programming and robotics lessons at local schools. Following the experience, they were asked to reflect through a blog post. These reflections were also shared with peers, so that preservice teachers could see how others approached the act of reflection. The course instructor also spent time engaging the preservice teachers in discussions surrounding their reflections to help further solidify the ideas that emerged during the *authentic activities* in *authentic contexts*. The W310 course instructor explained why she believed it was essential for the situated learning characteristic of *promoting reflection* to be embedded through all major course experiences, including this specific assignment:

> When preservice teachers don't reflect on an experience, an enormous learning opportunity is lost. Yes, designing and teaching a sample lesson is an incredibly valuable experience, but without

> reflection, students miss out on the chance to reexamine their successes and mistakes, and to further grow from the experience. I use reflection incredibly intentionally in my class, and I have found it to be an essential component of the learning process.

All other course instructors and the CEL program director also discussed the importance of *promoting reflection* in their interviews. For example, one instructor stated: "Reflection helps our preservice teachers bring everything together. They are able to connect the ideas they learn in class, with their experiences from the field, into a cohesive understanding of what it means to be a teacher." The second CEL instructor stated similar ideas on the value of reflection:

> Even though students don't necessarily see the value in the moment, reading my students' reflections is always one of my favorite activities. Through their reflections, I am able to see true growth in their understanding of ideas, and how they bring together different concepts and experiences to form new understandings.

The CEL program director also discussed the value of reflection both in her own course and throughout the CEL program as a whole:

> We have designed the CEL program to specifically focus on *promoting reflection*, largely through the use of blog posts that our preservice teachers write following their field experiences and other major course activities. In my own course, I use these reflections as an opportunity to check in on student understanding, and to make sure they are reaching our learning goals. I've found reflection to be most valuable when we also include peer feedback and discussion, so that we can have larger discussions surrounding everyone's reflections, rather than preservice teachers only focusing on their own experience.

Overall, this study's first research question sought to answer which situated learning characteristics were considered by instructors when designing courses. While all nine of Herrington and Oliver's (1995) situated learning characteristics were found in the syllabi analysis, the use of *authentic contexts*, *authentic activities*, and *reflection* were emphasized by all instructors as being major considerations in course design.

Research Question 2: What situated learning theory characteristics did teachers perceive valuable as they completed the CEL program? To answer this question, the researchers used data from preservice teachers' questionnaire responses, alumni teacher questionnaire responses, longitudinal interviews from four CEL teachers, and syllabi analysis. The analysis of the data indicated the two characteristics of situated learning theory; *authentic contexts* and *authentic activities* were perceived as most valuable by the teachers.

One student highlighted the CEL program's instruction methods in general: "The expectations of the CEL program are high. The CEL program utilizes the most up to date educational research to guide pedagogy and instruction methods for their students." The majority of preservice teachers and alumni reported in the questionnaire that they felt prepared to teach as a result of the CEL program due to the *authentic context and activities* embedded through out the CEL program.

One alumni teacher described how specifically the *authentic context* and *authentic activities* enabled her to succeed in her teaching job interviews:

> I was exposed to a variety of school settings, learning environments (formal/informal), and age groups (5-15). I was able to practice different strategies and methods with different types of technologies and find my own preferences and style. In [job] interviews, I was able to proficiently and expertly speak to the role of technology in the modern classroom, citing researched methods and strategies as well as a developed philosophy of technology and education. My knowledge and background with technology proved to be an advantage in the job market.

Similar comments were found in the preservice teacher questionnaire responses. For example, a preservice teacher emphasized that the types of experiences found throughout the CEL program would be similar to what they expect to find in the future: "[The CEL program] helps prepare you for future technologies that you might encounter in future classrooms." Another preservice teacher described a similar idea on the importance of experiences within *authentic contexts* during their time in the CEL program:

> It [the CEL program] gets you in the classroom sooner. It lets you experiment with iPads and be comfortable teaching with them like you will most likely have to do as a teacher. It teaches you many new tools. It gives you a new perspective on teaching. Not the traditional one.

Another preservice teacher mentioned the exposure to *authentic contexts* as an inspirational experience: "Although all of the books we read in this course were meaningful, the field trips that we took to see technology integration at its finest were really inspirational." Lastly another preservice teacher showed enthusiasm towards these authentic experiences: "LOVED all the field trips. They were so helpful."

Additionally, the syllabi analysis on all CEL courses revealed evidence of multiple, specific, real-world connections through *authentic contexts* and *authentic activities*. All courses contained activities focused on helping students build connections and interact with practitioners in the field. These activities included: field experiences, interview assignments, classroom observations, shadowing of technology leaders, the development and delivery of technology-based lessons, co-hosting local STEM nights, and leading robotics/programming activities at local schools. For example, listed in the W310 course assignments portion of the syllabus, students are required to participate in a weekly field experience where they helped plan and implement computer science-based lessons with local teachers in their respective future subject areas and grade levels.

The benefits of having *authentic contexts and authentic activities* during the CEL program came up in the longitudinal interviews as well. All four longitudinal interview participants indicated multiple, specific ideas for how they could apply what they learned through *authentic contexts* and *authentic activities* in their future/current schools and classrooms. For example, one preservice teacher described the necessity for thinking critically about technology usage in his future classroom, an idea stressed throughout the CEL curricula:

> The CEL program has given me a rationale for [technology usage] and a solid reason to say why I'm using this technology...I know how to use it effectively... and, it sounds quaint but not just for the sake of it. That's one thing I've learned and applied to my regular [field experience] teaching...if I don't have to do it with technology, I don't have to.

During round two of the longitudinal interview process, the same student stated that he felt very well prepared to student teach as a direct result of the real-world experiences offered in the CEL program. He went on to discuss two lessons learned from experiences working with other teachers in the field during the CEL program:

> I think the two things [that were most useful] were learning to use technology when appropriate and not just for the sake of it. And then also learning about searching for resources and finding new tools and apps and sites to help out. Two pretty big things and they have a larger meaning.

Finally, during round three of the longitudinal interview process, the same student who had graduated and become a social studies teacher, discussed that many of his current technology integration ideas come from previous experiences he “learned about from the CEL program.” Throughout the interview he discussed multiple approaches to integrating technology in his curriculum, including using QR codes, creating Smartboard activities, using Web 2.0 applications, using HTML to manage a class website, and multiple other examples covered throughout the CEL program curriculum and encountered during his numerous situated learning experiences.

CEL Program Revisions

Overall, this study occurred at the same time as a significant staff and instructor change. Based on this study, as well as the expertise of the new instructors, the instructors and CEL program director have made significant program adjustments since the time of this study to address these weaknesses. Additionally, the CEL program has a limited number of credits (only six courses). With these limited credits, one of the biggest reported challenges has been that preservice teachers need to pass the Pearson Computer Education Test 013. This test includes questions about web design, graphic design, general technology integration, library media skills, networking/hardware repair, as well as a few questions on computer programming. Instructors have reported challenges in incorporating all necessary content and curriculum into those six courses to build expertise across programming, pedagogy, and technology. As the CEL program is still relatively new, instructors are continuously revising and improving the courses to determine the most beneficial approaches. The course instructors strongly believe keeping situated learning theory at the core of course design will be beneficial in these efforts to improve the program. Additionally, through continuous data collection, systematic program monitoring, and iterative revision processes like this study, the instructors believe they will continue to improve the program. The CEL licensure program enrollment has been steadily increasing since 2012, and the enrollment numbers doubled in 2017.

DISCUSSION

Computer science education has become a newly prioritized focus area for U.S. K-12 education (The White House, 2016; The White House 2017).

With states recently proposing new CS standards, and the current CS teacher shortage, there is a demand for more highly qualified CS teachers (Hu, Heiner, Gagne, & Lyman, 2017; Lang et al., 2013). While some CS teachers have been recruited from existing inservice teacher populations (e.g., Hu et al., 2017), more preservice teacher education programs need to recruit and train future CS teachers to meet the current demand (Hu et al., 2017; Lang et al., 2013; The White House, 2017).

However, as computer science teacher education is still a relatively new field, we need to explore best practices to prepare computer science teachers. We can draw upon the literature surrounding strong teacher education programs in general. Several teacher education programs have used a situated learning perspective to immerse students in authentic learning contexts to make learning more meaningful (e.g., Hur, Cullen, & Brush, 2010; Meyers & Lester, 2013). This approach has potential because these authentic contexts can help teachers improve their problem-solving skills and better understand how to apply the knowledge they have learned in their courses to their future classrooms (Meyers & Lester, 2013).

Perhaps the strongest result from this study was the importance of field experiences. Many studies have expressed the importance of field experiences on preservice teacher development (e.g., Zeichner, 2010). Field experiences provide preservice teachers with opportunities to link academic and practitioner knowledge, practice skills, and begin to build the types of expertise they will need in the field (Zeichner, 2010). In the CEL program, instructors utilized the situated learning approach to specifically incorporate *authentic contexts* and *authentic activities* through the use of a wide range of field experiences. The teachers (both preservice and alumni) described these opportunities as valuable because they provided insight into the types of challenges and experiences they would face in the field and helped them put their CEL skills into practice. In turn, preservice teachers described feeling more prepared for their future classrooms. Therefore, we suggest that preservice computer science programs attempt to integrate learning opportunities that incorporate *authentic contexts* and *authentic activities*.

It is critically important to provide preservice teachers with these experiences, although the instructors in the CEL program reported facing challenges with finding enough suitable placements. However, other programs have overcome similar challenges. For example, Ragonis and Hazzan (2009) set up a tutoring experience for their preservice teachers instead of the traditional K-12 classroom field experience. Preservice teachers enrolled in a two-semester methods course that required each of them to tutor a high school student currently enrolled in a CS course. Each tutoring pair met for two five-session cycles, with sessions held once every two weeks. This is a unique approach to help preservice teachers understand how to teach computer science. Although they miss out on classroom management aspects of typical field experiences, they are provided with rich opportunities to experiment with computer science pedagogy and student learning (Ragonis & Hazzan, 2009).

In another study, Bell, Frey, and Vasserman (2014) had four preservice teachers (three music, one art) assist in a four-week summer programming camp for sixth through ninth grade students. In this study, the preservice teachers were required to help out at first, then gradually modified and presented their own lessons incorporating music and art into programming activities. Not only were the preservice teachers "effective in delivering programming content to the students in a way that promoted an increase in student interest in programming while incorporating their context-specific materials into the lessons," (Bell et al., p. 191) but they also described feeling confident in their abilities to explore and integrate Scratch more within their future curriculums. Therefore, teacher education programs can consider creative approaches such as tutoring, afterschool, and/or summer programs to provide learning opportunities for preservice teachers to apply their knowledge in authentic contexts.

One final interesting finding was that although faculty stressed *promoting reflection* in their design of the program, teachers did not mention reflection. Reflection is critical for preservice teachers because it helps make connections between academic and practical knowledge (Orland-Barak & Yinon, 2007) and may also improve teaching effectiveness (Willard-Holt & Bottomley, 2000). Reflections on field experiences are particularly important because they can help preservice teachers reframe previous assumptions about teaching and better understand the challenges teachers face (Freese, 2006). Hatton and Smith (1995) purported that there were four basic strategies to facilitate teacher reflections: (1) action research projects, (2) case studies, (3) microteaching and other supervised practicum experiences, and (4) structured curriculum tasks. Others have suggested benefits of integrating reflection-based tasks within field experiences (e.g., Freese, 2006; Wedman & Martin, 1986) although preservice teachers may have difficulty with this process (Liakopoulou, 2012).

Although the syllabi analysis showed that preservice teachers completed reflections in every course, once they had completed the reflection process, little was done to follow up. To further draw upon situated learning theory, the CEL instructors could more fully incorporate the situated learning characteristic of *collaborative construction of knowledge* to better synthesize knowledge gained from the reflection process. Collaborative reflection processes have been suggested to be beneficial for improving preservice teachers' reflective practices (e.g., Cobb, McClain, De Silva, & Dean, 2003; Nicholson & Bond, 2003). By extending upon reflection activities to make them more collaborative, teachers might find more value in these reflective experiences. One way to do that can be through dialogue and conversations about these reflections in classes (Orland-Barak & Tillema 2006). Another way can be for teachers to bring in their reflections from an authentic activity to a class meeting to share with their peers, and articulate how their experiences fit within theoretical frameworks, then collaboratively work with peers through discussion to produce new ways of thinking (Woods, 1995). As a result of such extended debriefing on reflections, students can share their new collaboratively constructed knowledge through a group infographic or through a collaboratively constructed best-practices blog post. Additionally, these collaborative processes would also enable preservice teachers to explain their rationale and thought processes, which is a component of making *tacit knowledge to be made explicit*. This is one of the situated learning characteristics that was minimally addressed in CEL course syllabi, and was not discussed by any CEL instructors in their interviews.

Implications for Teacher Education

Currently, there are few preservice teacher education programs that prepare computer science teachers in the U.S (Gal-Ezer & Stephenson, 2010; Lang et al., 2013). However, there is a growing need to create programs to meet the increased demand for CS teachers (Lang et al., 2013). When designing these programs, we need to use research-based theories and practices that support the development of preservice teachers. Based on the results of this study, we offer three main recommendations for similar CS preservice teacher programs: incorporate field experiences with partnerships, incorporate explicit reflections, and focus on field-defined CS pedagogical content knowledge.

Based on our study, we found that our preservice teachers valued their field experiences. Therefore, we recommend finding ways to incorporate field experiences whenever possible. To increase the availability of field experiences, teacher preparation programs should develop sustained partnerships with local schools, teachers, and even after school programs. In the latest report on "Priming the Computer Science Teacher Pump," DeLyser, Goode, Guzdial, Kafai, and Yadav (2018) also described how the establishment of partnerships with local school districts could advance preservice teacher preparation for teaching CS.

The other major finding was related to reflection; although faculty described the importance of reflection, no preservice teacher mentioned this as a valuable contribution of the CEL program. However, because other studies have shown the importance of reflection on preservice teacher development (Freese, 2006; Orland-Barak & Yinon, 2007), we suggest incorporating reflection practices and opportunities intentionally and continuously throughout the program. It may be necessary for faculty to be more transparent in the rationale for the incorporation of reflection. When preservice teachers acknowledge what they have learned through reflection, they are more likely to actively incorporate those learned principles into their practices, which is the most important aspect of helping promote change in preservice teacher practices.

One of the struggles associated with preparing CS teachers is the lack of information on CS pedagogical content knowledge. Although some scholars have attempted to define this (Webb, Davis, Bell, Katz, Reynolds, Chambers, Syslo, 2017), standards and best practices associated with teaching CS are still being formed (DeLyser et al., 2018). There have been standards for students (e.g., Parker & DeLyser, 2017; Seehorn & Calyborn, 2017), but the CS education research community is still working on definitions for teachers (Yadav et al., 2016). For this program, instructors described struggling with the large number of various standards to address. The instructors were required to address the ISTE Computer Science Educator standards, the Pearson Computer Education exam, and the standards for the courses that teachers with the Computer Education license would be allowed to teach (see Tables 7-12). These standards vary widely and incorporate elements of web design, educational technology, computational thinking, computer science, and even digital citizenship. If there were more alignment between what CS teachers need to be prepared for, licensure programs could be more focused and clear. With a limit of six courses (as this is an add-on license), programs need to be intentional about how preservice teachers are prepared.

Situated learning implications. Additionally, this study found that a situated learning approach allowed CEL instructors to focus on the authentic elements necessary to translate theory into practice. For those programs looking to implement a CEL program based on situated learning theory, the following activities are suggestions for targeting the nine situated learning characteristics (see Table 6).

Table 6
Situated learning characteristics and example activities

Characteristic	Activity Example
Provide authentic contexts	• Field experiences (e.g., Zeichner, 2010) • Shadowing
Provide authentic activities	• Develop and deliver lesson plans • Provide professional development
Provide access to expert performances	• Video cases (e.g., Brush & Saye, 2009) • Guest speakers
Provide multiple roles and perspectives	• Panel discussions • Structured academic controversies (e.g., Johnson & Johnson, 1985).
Support collaborative construction of knowledge	• Group projects (e.g., research presentations, grant challenges) • Cross-curricular projects
Provide coaching and scaffolding	• Teacher support and feedback during and after on-site lesson delivery • Teacher modeling specific strategies and pedagogical approaches with feedback
Promote reflection	• Blogging (e.g., video selfies, online text) • Class discussions after field experiences
Provide articulation for making tacit knowledge explicit	• Making pedagogy transparent (e.g., teacher explains pedagogical decisions) • Recording field experiences and students articulating decisions made during those experiences
Provide integrated assessment	• Providing formative feedback • Evaluating entire learning process, not just final product

In summary, the authors suggest taking a holistic perspective for similar CS teacher education program design that includes the standards, learning theories, and specific skills preservice teacher must develop. This type of structured approach may also help with preservice teacher recruitment, retention, and placement within computer science education.

References

Bagley, W. C. (1933). The Ideal Preparation of a Teacher of Secondary Mathematics from the Point of View of an Educationist. *The Mathematics Teacher*, *26*(5), 271-276.

Bell, R. L., Maeng, J. L., & Binns, I. C. (2013). Learning in context: Technology integration in a teacher preparation program informed by situated learning theory. *Journal of Research in Science Teaching*, *50*(3), 348-379.

Bell, S., Frey, T., & Vasserman, E. (2014, March). Spreading the word: introducing pre-service teachers to programming in the K12 classroom. In *Proceedings of the 45th ACM technical symposium on Computer science education* (pp. 187-192). ACM.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32-42.

Brush, T., & Saye, J. (2009). Strategies for preparing preservice social studies teachers to effectively integrate technology: Models and practices. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 46-59.

Cobb, P., McClain, K., De Silva Lamberg, T. and Dean, C.2003. Situating teachers' instructional practices in the institutional setting of the school and district. *Educational Researcher*, *32*(6): 13–25.

Darling-Hammond, L. (2006). Constructing 21st-century teacher education. *Journal of Teacher Education*, *57*(3), 300-314.

DeBoer, G. (1991). A history of ideas in science education: Implications for practice. New York: Teachers College Press.

DeLyser, L., Goode, J., Guzdial, M., Kafai, Y., & Yadav, A. (2018). *Priming the computer science teacher pump: Integrating computer science education into schools of education*. New York: CSforAll.

Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process*. Lexington, MA: Heath.

De Vaus, D. (2014). *Surveys in Social Research* (6th ed). New York, NY: Routledge.

Ericson, B., Guzdial, M., & Biggers, M. (2007, March). Improving secondary CS education: progress and problems. In *ACM SIGCSE Bulletin* (Vol. 39, No. 1, pp. 298-301). ACM.

Feiman-Nemser, S., & Buchmann, M. (1987). When is student teaching teacher education?. *Teaching and Teacher Education*, *3*(4), 255-273.

Freese, A. R. (2006). Reframing one's teaching: Discovering our teacher selves through reflection and inquiry. *Teaching and Teacher Education*, *22*(1), 100-119. doi: 10.1016/j.tate.2005.07.003

Gal-Ezer, J., & Stephenson, C. (2010). Computer science teacher preparation is critical. *ACM Inroads, 1*(1), 61-66.

Gal-Ezer, J., & Stephenson, C. (2014). A tale of two countries: Successes and challenges in k-12 computer science education in Israel and the united states. *ACM Transactions on Computing Education (TOCE)*, *14*(2), 8.

Goode, J. (2007). If you build teachers, will students come? The role of teachers in broadening computer science learning for urban youth. *Journal of Educational Computing Research, 36*(1), 65-88.

Grover, S., & Pea, R. (2013). Computational Thinking in K–12 A Review of the State of the Field. *Educational Researcher*, *42*(1), 38-43. doi: 10.3102/0013189X12463051.

Hatton, N., & Smith, D. (1995). Reflection in teacher education: Towards definition and implementation. *Teaching and Teacher Education*, *11*(1), 33-49.

Herrington, J., & Oliver, R. (1995). Critical characteristics of situated learning: implications for the instructional design of multimedia. In *Proceedings of ASCILITE 95 conference*. 253–262.

Hu, H. H., Heiner, C., Gagne, T., & Lyman, C. (2017, March). Building a Statewide Computer Science Teacher Pipeline. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education* (pp. 291-296).

Hur, J. W., Cullen, T., & Brush, T. (2010). Teaching for application: A model for assisting pre-service teachers with technology integration. *Journal of Technology and Teacher Education*, *18*(1), 161-182.

ISTE Standards. (2007). Retrieved March 06, 2016, from: http://www.iste.org/standards/iste-standards

Johnson, D. W., & Johnson, R. (1985). Classroom conflict: Controversy versus debate in learning groups. *American Educational Research Journal*, *22*(2), 237-256. doi: 10.3102/00028312022002237

Klopfer, L. E. (1969), The teaching of science and the history of science. *Journal of Research in Science Teaching*., 6: 87–95.

Kopcha, T. J., & Sullivan, H. (2007). Self-presentation bias in surveys of teachers' educational technology practices. *Educational Technology Research and Development*, *55*(6), 627-646.

Lang, K., Galanos, R., Goode, J., Seehorn,D., Trees, F., Phillips, P., & Stephenson, C. (2013). Bugs in the System: Computer Science Teacher Certification in the US. The Computer Science Teachers Association and The Association for Computing Machinery.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge university press.

Lee, A. (2015). Determining the Effects of Computer Science Education at the Secondary Level on STEM Major Choices in Postsecondary Institutions in the United States. *Computers & Education*. doi: 10.1016/j.compedu.2015.04.019

Liakopoulou, M. (2012). The Role of Field Experience in the Preparation of Reflective Teachers. *Australian Journal of Teacher Education, 37*(6). http://dx.doi.org/10.14221/ajte.2012v37n6.4

McLellan, H. (1996). Situated learning: Multiple perspectives. *Situated learning perspectives*, 5-17.

Menekse, M. (2015). Computer science teacher professional development in the United States: a review of studies published between 2004 and 2014. *Computer Science Education*, *25*(4), 325-350.

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.

Meyers, S., & Lester, D. (2013). The Effects of Situated Learning Through a Community Partnership in a Teacher Preparation Program. *Sage Open*, *3*(3), 1-9.

Miles, M. B., & Huberman, A. M. (1984). Drawing valid meaning from qualitative data: Toward a shared craft. *Educational Researcher, 13*(5), 20-30.

Monk, D. H. (1994). Subject area preparation of secondary mathematics and science teachers and student achievement. *Economics of Education Review*, *13*(2), 125-145.

Orland-Barak, L., & Tillema, H. (2006). The 'dark side of the moon': A critical look at teacher knowledge construction in collaborative settings. *Teachers and Teaching: theory and practice*, *12*(1), 1-12.

Orland-Barak, L., & Yinon, H. (2007). When theory meets practice: What student teachers learn from guided reflection on their own classroom discourse. *Teaching and Teacher Education*, *23*(6), 957-969.

Parker, M. C., & DeLyser, L. A. (2017). Concepts and Practices: Designing and Developing A Modern K-12 CS Framework. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education*, 453-458.

Patel, P. (October 2, 2017). More Teachers, Fewer 3D Printers: How to Improve K–12 Computer Science Education. IEEE Spectrum. https://spectrum.ieee.org/tech-talk/at-work/education/what-500-million-could-mean-for-k12-computer-science-education

Patton, M. (2002). *Qualitative research and evaluation methods*. Thousand Oaks. Sage.

Pellegrino, J. W., & Hilton, M. L. (Eds.). (2013). *Education for life and work: Developing transferable knowledge and skills in the 21st century*. National Academies Press.

Phillips, P., & Stephenson, C. (2013). *Bugs in the System: Computer Science Teacher Certification in the U.S.* New York: Computer Science Teachers Association.

Ragonis, N., & Hazzan, O. (2009). A tutoring model for promoting the pedagogical-disciplinary skills of prospective teachers. *Mentoring & Tutoring: Partnership in Learning, 17*(1), 67-82.

Schön, D. A. (1987). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions*. Jossey-Bass.

Seehorn, D., Carey, S., Lee, I., Moix, D., O'Grady-Cuniff, D., Boucher Owens, B., Stephenson, C., & Verno, A. (2011). *The CSTA K–12 computer science standards*. New York, NY: Computer Science Teachers Association.

Seehorn, D., & Clayborn, L. (2017). CSTA K-12 CS Standards for All. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education*. 730-730.

Simard, C., Stephenson, C., & Kosaraju, D. (2010). Addressing Core Equity Issues in K–12 Computer Science Education: Identifying Barrier and Sharing Strategies. *The Anita Borg Institute and the Computer Science Teachers Association. Palo Alto, CA*.

Southern Regional Education Board (2016). *Bridging the Computer Science Education Gap: Five Actions States Can Take*. SREB Commission on Computer Science and Information Technology. Retrieved from: http://www.sreb.org/sites/main/files/file-attachments/cs_commission_2016_0.pdf

Stake, R.E. (1995). The Art of Case Study Research. London: Sage Publications.

Stake, R.E. (2003). Case Studies (134-164) in Denzin, N.K. & Lincoln, Y. (eds) (2003). Strategies of Qualitative Inquiry (2nd ed). London: Sage.

Stanton, J., Goldsmith, L., Adrion, W.R., Dunton, D., Hendrickson, K.A., Pterfreund, A. Yongpradit, P., Zarch R. & Zinth, J.D. (2017, March 1). State of the States Landscape Report: State-Level Policies Supporting Equitable K–12 Computer Science Education. Retrieved from: https://www.ecs.org/ec-content/uploads/MassCAN-Full-Report-v10.pdf

Stemler, S. (2001). An overview of content analysis. *Practical Assessment, Research & Evaluation*, *7*(17), 137-146.

The White House (2017). *Presidential Memorandum for the Secretary of Education.* Retrieved from: https://www.whitehouse.gov/the-press-office/2017/09/25/memorandum-secretary-education

The White House (2016). *FACT SHEET: President Obama Announces Computer Science for All Initiative*. Retrieved from: https://obamawhitehouse.archives.gov/the-press-office/2016/01/30/fact-sheet-president-obama-announces-computer-science-all-initiative-0

Tucker, A., Deek, F., Jones, J., McCowan, D., Stephenson, C., & Verno, A. (2003). A model curriculum for K–12 computer science. *Final Report of the ACM K-12 Task Force Curriculum Committee, CSTA*.

United States Department of Education (2016). 2016 Title II Reports: National Teacher Preparation Data. Retrieved from https://title2.ed.gov/Public/Home.aspx

U.S. Bureau of Labor Statistics. (2016). U.S. Department of labor, Occupational outlook handbook, 2016 edition, computer and information technology. Retrieved from: https://www.bls.gov/ooh/computer-and-information-technology/home.htm

Webb, M., Davis, N., Bell, T., Katz, Y. J., Reynolds, N., Chambers, D. P., & Sysło, M. M. (2017). Computer science in K-12 school curricula of the 2lst century: Why, what and when?. *Education and Information Technologies*, *22*(2), 445-468.

Wedman, J. M., & Martin, M. W. (1986). Exploring the development of reflective thinking through journal writing. *Reading Improvement*, *23*(1), 68.

Willard-Holt, C., & Bottomley, D. (2000). Reflectivity and effectiveness of preservice teachers in a unique field experience. *Action in Teacher Education*, *22*(2), 76-89. doi: 10.1080/01626620.2000.10463007

Wilson, C., Sudol, L. A., Stephenson, C., & Stehlik, M. (2010). *Running on empty: The failure to teach K-12 computer science in the digital age*. New York, NY: The Association for Computing Machinery and the Computer Science Teachers Association.

White, M. D., & Marsh, E. E. (2006). Content analysis: A flexible methodology. *Library Trends*, *55*(1), 22-45.

Yadav, A., Hong, H., & Stephenson, C. (2016). Computational thinking for all: pedagogical approaches to embedding 21st century problem solving in K-12 classrooms. *TechTrends*, *60*(6), 565-568.

Young, M. F. (1993). Instructional design for situated learning. *Educational Technology Research and Development, 41*(1), 43-58. http://dx.doi.org/10.1007/BF02297091

Zeichner, K. (2010). Rethinking the connections between campus courses and field experiences in college-and university-based teacher education. *Journal of Teacher Education, 61*(1-2), 89-99.

APPENDIX A (TABLES 7-12)

Table 7

Detailed overview of W200 course alignment with ISTE standards and situated learning characteristics

Course Title	W200: Computers in Education
Course Content	This course is required for all undergraduate preservice teachers at Indiana University. This course provides an introduction to using technology to support teaching and learning. Students complete a variety of assignments, aligned with their content area, in order to gain a foundational understanding of how students can benefit from technology integration in the classroom.
Field Experiences	Students conducted a service learning project where they partnered with a classroom teacher to design and implement a technology-based lesson for their classroom.
Situated Learning Characteristics	Provide authentic activities Provide access to expert performances Support collaborative construction of knowledge Provide coaching and scaffolding Promote reflection
ISTE-T Standards	ISTE-T 1. Facilitate and inspire student learning and creativity ISTE-T 2. Design and develop digital age learning experiences and assessments ISTE-T 3. Model digital age work and learning ISTE-T 4. Promote and model digital citizenship and responsibility ISTE-T 6. Engage in professional growth and leadership
ISTE-C Standards	ISTE-C 5. Digital Citizenship ISTE-C 6. Content knowledge and professional growth
ISTE-CSE Standards	Not addressed in this course at this time

Table 8
Detailed overview of W210 course alignment with ISTE standards and situated learning characteristics

Course Title	W210: Survey of Computer-Based Education
Course Content	This course focused on introductory coding and programming skills using HTML, CSS, and robotics. Additionally, students participated in several small field experiences as well as host a STEM night at a local school at the end of the semester.
Field Experiences	During 2012-2014, candidates assisted with professional development activities or helping design instructional support materials/job aids for iPads, volunteering approximately 10-15 hours total.
Situated Learning Characteristics	Provide authentic contexts Provide authentic activities Provide access to expert performances Support collaborative construction of knowledge Provide coaching and scaffolding Promote reflection Provide articulation for making tacit knowledge explicit Provide integrated assessment
ISTE-T Standards	ISTE-T 1. Facilitate and inspire student learning and creativity ISTE-T 2. Design and develop digital age learning experiences and assessments ISTE-T 3. Model digital age work and learning ISTE-T 4. Promote and model digital citizenship and responsibility ISTE-T 6. Engage in professional growth and leadership
ISTE-C Standards	Not addressed in this course at this time.
ISTE-CSE Standards	ISTE-CSE 1. Knowledge of content ISTE-CSE 2. Effective teaching and learning strategies ISTE-CSE 3. Effective learning environments

Table 9
Detailed overview of W220 course alignment with ISTE standards and situated learning characteristics

Course Title	W220: Technical Issues in Computer-Based Education
Course Content	This course focused on hardware, software, networking, and programming. This course covered PHP language, in order to provide students with a foundational understanding of coding.
Field Experiences	During 2012-2014, no field experiences were required for this course.
Situated Learning Characteristics	Provide authentic activities Provide access to expert performances Support collaborative construction of knowledge Provide coaching and scaffolding Promote reflection
ISTE-T Standards	Not addressed in this course at this time
ISTE-C Standards	Not addressed in this course at this time.
ISTE-CSE Standards	ISTE-CSE 1. Knowledge of content ISTE-CSE 2. Effective teaching and learning strategies ISTE-CSE 3. Effective learning environments ISTE-CSE 4. Effective professional knowledge and skills

Table 10
Detailed overview of W310 course alignment with ISTE standards and situated learning characteristics

Course Title	W310: Integrating Technology in K-12 Classrooms
Course Content	This course modeled how preservice teachers could teach computer science using Code.org's CS Principles curriculum. Additionally, there were required field experiences of 10-15 hours where students were asked to design and implement computer science-based lesson plans in a local K-12 classroom.
Field Experiences	During 2012-2014, preservice teachers conducted numerous field experiences in their future subject areas and grade levels. Preservice teachers designed and implemented lessons on robotics, programming, and general technology. These lessons were implemented on their own and with the help of cooperating teachers at local schools
Situated Learning Characteristics	Provide authentic contexts Provide authentic activities Provide access to expert performances Provide multiple roles and perspectives Support collaborative construction of knowledge Provide coaching and scaffolding Promote reflection Provide articulation for making tacit knowledge explicit Provide integrated assessment
ISTE-T Standards	ISTE-T 1. Facilitate and inspire student learning and creativity ISTE-T 2. Design and develop digital age learning experiences and assessments ISTE-T 3. Model digital age work and learning ISTE-T 4. Promote and model digital citizenship and responsibility ISTE-T 6. Engage in professional growth and leadership
ISTE-C Standards	ISTE-C 3. Digital age learning environments
ISTE-CSE Standards	ISTE-CSE 1. Knowledge of content ISTE-CSE 2. Effective teaching and learning strategies ISTE-CSE 3. Effective learning environments

Table 11
Detailed overview of W435 course alignment with ISTE standards and situated learning characteristics

Course Title	W435: Technology Leadership in K-12
Course Content	This course focused on school-wide implementation of technology. Students were required to spend time shadowing a current technology leader at a local school. The topics of troubleshooting, professional development design, and technology budgeting/funding were also addressed.
Field Experiences	During 2012-2014, preservice teachers spent one work day shadowing a technology coach or coordinator at a local school. Prior to this experience, they had conducted research on the school to better understand the technology resources available, and each preservice teacher came prepared with questions to gain a better understand of the technology needs, resources, and requirements at the school/district level.
Situated Learning Characteristics	Provide authentic contexts Provide authentic activities Provide access to expert performances Provide multiple roles and perspectives Support collaborative construction of knowledge Provide coaching and scaffolding Promote reflection Provide articulation for making tacit knowledge explicit
ISTE-T Standards	ISTE-T 6. Engage in professional growth and leadership
ISTE-C Standards	ISTE-C 1. Visionary leadership ISTE-C 2. Teaching, learning, and assessments ISTE-C 3. Digital age learning environments ISTE-C 4. Professional development and program evaluation ISTE-C 5. Digital citizenship ISTSE-C 6. Content knowledge and professional growth
ISTE-CSE Standards	Not addressed in this course at this time.

Table 12
Detailed overview of W410 course alignment with
ISTE standards and situated learning characteristics

Course Title	W410: Practicum in Computer-Based Education
Course Content	During the practicum experience, preservice teachers were asked to plan and implement two technology-based lessons over the course of the semester. There was a requirement for the preservice teachers to not only teach their students how to use technology, but also to integrate that technology in their primary license subject area in a meaningful way. Throughout the semester students also completed reflections and blog posts outlining their classroom progress and experiences.
Field Experiences	This entire course is a practicum experience, and all activities are done within the field.
Situated Learning Characteristics	Provide authentic contexts Provide authentic activities Provide access to expert performances Provide multiple roles and perspectives Support collaborative construction of knowledge Provide coaching and scaffolding Promote reflection Provide articulation for making tacit knowledge explicit Provide integrated assessment
ISTE-T Standards	ISTE-T 1. Facilitate and inspire student learning and creativity ISTE-T 2. Design and develop digital age learning experiences and assessments ISTE-T 3. Model digital age work and learning ISTE-T 4. Promote and model digital citizenship and responsibility ISTE-T 6. Engage in professional growth and leadership
ISTE-C Standards	Not addressed in this course at this time.
ISTE-CSE Standards	ISTE-CSE 1. Knowledge of content ISTE-CSE 2. Effective teaching and learning strategies ISTE-CSE 3. Effective learning environments ISTE-CSE 4. Effective professional knowledge and skills