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Unpacking Preservice Elementary Education Majors' Pre-Covid Experiences with Instructional Technology: Implications for Post-Covid Technology Use

Catherine L Quinlan*

Howard University, Washington, DC, USA
*Correspondence: E-mail: drcatherinequinlan@gmail.com

Abstract

Virtual learning during the Covid-19 pandemic has made the effective use of technology, as a learning tool, more important than it has ever been. One of the challenges within instructional technology courses for preservice elementary education majors was whether or not to train students to use technology as a means to an end or to focus on technology skills. Instructional technology courses could reinforce traditional approaches or encourage higher order thinking or acquisition of twenty first century skills for formal or informal settings. This study explored the pre-Covid inclinations and experiences of undergraduate preservice teachers who engaged in various types of technology that facilitated both the learning of content and the building of technological skills to varying degrees. This basic qualitative exploratory study looked at preservice teachers' perceptions about their engagement with the technologies and about their own capabilities. The findings show connections that were most salient to the preservice teachers. These pre-Covid pandemic findings have implications for the current state of instructional technology and learning using technology in the post-Covid pandemic era.

Keywords: Blacks, preservice elementary education majors, preservice teachers, instructional technology, ISTE standards

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1. Introduction

Elementary education was cited as one of the indicators for Science and Engineering in the 2014 and 2018 National Science Foundation's (NSF) National Science Board Statistics Reports [1, 2]. The 2014 report showed that most elementary teachers gained certifications in an undergraduate program but were least likely among teachers to experience professional development in science [1]. Thus, the preservice undergraduate and graduate elementary education program is a very defining experience for prospective elementary teachers. Elementary teachers displayed the least confidence in their ability to teach science compared with math; very few (17%) felt prepared to teach the physical sciences and even fewer (4%) felt prepared to teach engineering. This in turn impacts their students in the classroom. While the 2018 report noted that there was limited data on the role of instructional technology [2], the 2018 report acknowledged that there was reason to believe that the effectiveness in science learning could be linked to effective instructional technology implementation [2].

An instructional technology course for education majors varies as widely as the use of technology in the K-12 classroom. Often training in instructional technology may take the form of learning how to use various platforms such as Google Classroom or Zoom. What if instead, instructional technology was used as a conduit for learning various subject areas, such as STEM, humanities, and social sciences, and for developing other skills? Technology as a virtual learning and instructional tool is now more important than it has ever been. While this instructional technology course implementation took place before the Covid-19 pandemic, the results have important implications for understanding teacher performance during and post-Covid-19.

The challenge to effectively train preservice students and hence future teachers predates the pandemic. One important consideration for an instructional technology course for the researcher who is also the author and instructor, was whether to train students to use technology as a means to an end, or to focus only on technology skills or conduit platforms. The perspective of the instructor was that technology skill development could be used to reinforce traditional methods of learning or encourage acquisition of twenty first century skills for teaching in a formal or informal setting. Thus, course design had two main goals—first, to provide students with the opportunity to engage in science and other subject content areas, and second to provide opportunity to build technology skills in the hopes that students might see the various technologies as useful learning tools and higher order thinking tools for the elementary classroom. The research questions explored were: *What are students' perceptions about their own capabilities and preferences for the technology? What themes and patterns emerge in students' engagement with the various instructional technology? What patterns emerge in students' connections to subject content matter and ideas about teaching and learning?*

The literature review that follows situates this exploratory qualitative study, which took place prior to the Covid-19 pandemic, in pre-pandemic research. Rather, providing a frame of reference into pre-pandemic understandings that went into conducting this research was considered important.

2. Literature review

2.1. Technology embeddedness and standards

Technology use, access, implementation, and standards vary from state to state and across school districts. Some state standards encourage embeddedness, such as the District of Columbia's Office of State Superintendent of Education's (OSSE) "Embedded Technology Standards" [3]. However, there are differences in what this "embeddedness" means and looks like. OSSE's standards showed embedded technology in Reading/English Language Arts with categories such as "Research," "Writing," "Media," in Science such as "Science and Technology," and in other subject areas such as Physical Education, Art, Music, and Health [3].

The 2017 International Society for Technology in Education (ISTE) standards for educators identified seven areas for development in technology—educator as learner, leader, citizen, collaborator, designer, facilitator, and analyst [4]. For example, educators "collaborate and co-learn with students to discover and use new digital resources and diagnose and troubleshoot technology issues" [4]. There were seven learning categories for students—empowered learner, digital citizen, knowledge constructor, innovative designer, computational thinker, creative communicator, and global collaborator. As innovative designer, "students develop, test and refine prototypes as part of a cyclical design process" [5]. However, how instructional technology standards is translated into classroom practice has always been teacher specific. Though, there is now more emphasis on what these best practices are during the virtual post-Covid pandemic era.

In the 2017 National Education Technology Plan (NETP) Update by the Office of Educational Technology (OET) titled "Reimagining the Role of Technology in Education," [6] the learning goals were: "All learners will have engaging and empowering learning experiences in both formal and informal settings that prepare them to be active, creative, knowledgeable, and ethical participants in our globally connected society" [6]. The plan stated: "Mindful of the learning objectives, educators might design learning experiences that allow students in a class to choose from a menu of learning experiences—writing essays, producing media, building websites, collaborating with experts across the globe in data collection …" [6]. All in all, the report encourages the use of technology to develop critical thinking skills and other twenty first century skills. Thus, there is a role for including activities such as coding into the instructional technology course for elementary teachers to give them an opportunity to engage with software that might carry over into informal settings or help students develop critical skills.

2.2. Using technology to support spatial learning

Even though elementary teachers generally do not teach science, integrating technology such as Geographical Information Systems (GIS) could facilitate the development of skills required for science at an early age. Newcombe [7] noted that scientists and engineers have good spatial skills and that people with good spatial skills do well in science [7]. The National Research Council [8] found that GIS could help students develop the spatial skills important for success in science and engineering, and defined spatial thinking as follows:

> Spatial thinking is based on a constructive amalgam of three elements: concepts of space, tools of representation, and processes of reasoning. It depends on understanding the meaning of space and using the properties of space as a vehicle for structuring problems, for finding answers, and for expressing solutions [8].

ArcGIS (Aeronautical Reconnaissance Coverage GIS) online was one example of a GIS mapping software that used various kinds of data, and that could be used to practice spatial thinking. Kerr [9] found that the use of ArcGIS online in a middle and secondary social studies teacher educator program promoted critical thinking and interdisciplinarity in the course content. Likewise, Jo [10] explored the beliefs and dispositions of students using ArcGIS online and found that students displayed positive attitudes, that using ArcGIS online was an "eye-opening experience," and that GIS could promote high level thinking in students [10].

2.3. Research with preservice and in-service teachers

Trautmann and MaKinster [11] found that the use of a flexible adaptive model for training secondary science teachers to use geospatial technology catered to the diverse needs, skills, and motivations of the teachers. While one teacher felt "excited" and "intimidated" by her lack of experience, she demonstrated "Technological Pedagogical Knowledge … by her ability to switch from one tool to the next on the fly" [11]. Even though she experienced failures using both ArcMap and then Google Earth, she switched to Mapping Gateway in her Earth Science ninth grade class. Another teacher, who had students that he felt were challenging to motivate and that had academic difficulties, found that using geospatial technology helped his students to "visualize key science concepts" [11]. This teacher found himself evaluating his lessons to see if they could be taught using GIS but at the same time felt it was important to take students outdoors. Thus, his goal was to use technology to enhance the lessons and not to replace good pedagogy. Another teacher, who had considerable experience with GPS (Global Positioning System) and Google Earth, created tours to demonstrate certain concepts for students. He used it more with his Environmental science course than with his Earth science, and indicated that his use depended on the science concept to be learned. For example, he preferred hands on manipulation when teaching rocks and minerals but found the technology more useful when teaching meteorology.

Dickes *et al.* [12] described the implementation of ViMAP, "an agent-based programming and computational modeling platform," over 7 months in an elementary 3rd grade classroom with 14 African American and one (1) Latino student in a population with over 95% on free or reduced lunch. Dickes *et al.* [12] showed that the teacher Emma changed positions from observing the instruction by the researchers in her classroom, to an emergent co-designer, and then to sole instructor, as she developed agency. They noted that "she wanted to expand ViMAP's pedagogical impact by making more explicit connections to required 3rd grade mathematics concepts" [12]. Her observations led her to make more explicit connections to the mathematical concepts students needed to learn. Dickes *et al.* [12] noted that even "as a novice programmer herself with no prior experience in programming, the teacher Emma saw physical enactment of computational commands as a valuable form of sensemaking and encouraged activity design which scaffolded student thinking in similar ways". Similarly, this current study unpacked and explored whether elementary preservice teacher engagement in these activities might lead them to perceive any potential pedagogical benefits for their future classrooms.

The hope of every preservice teacher program is that students transfer their learning from the college setting to the elementary classroom setting. Bransford *et al.* [13] cite three kinds of transfers. Vertical transfer is the transfer of skills that are important to achieve another skill such as "writing letters of the alphabet are useful to writing words." Near transfer refers to "transfer from one school task and a highly similar task" [13]. Lastly, far transfer refers to transfer "from school subjects to non-school settings … (Klausmeier, 1985)" [13]. The importance of transfer is even more critical now, as educators sought to transfer teaching strategies from the classroom setting to the virtual environment during the Covid pandemic and after.

In some ways, studies using technology looked at the degree of near transfer or far transfer. Zha *et al.* [14] used "a block programming app called Hopskotch" to help students develop computational thinking. Participants were fifteen preservice teachers who were elementary education majors in an educational technology course. Their findings showed that participants scored significantly better on post quizzes than on their pre quizzes. Thus, their use of the technology transferred into computational thinking exhibited in quiz scores. However, far transfer of skills to the elementary classroom can be difficult to measure. The researchers measured preservice teachers' perceptions about their own ability to transfer learning. Zha *et al.*'s [14] noted that measures of attitudes showed "borderline" significant improvement in only one item "I doubt that I can solve problems by using computer applications." Other improvements, though insignificant, included items such as, "I expect to use software in my future educational and teaching work," "I expect to use computer applications for future projects involving teamwork," and "I can learn to understand computer concepts" [14]. While some items remained the same, a decrease was seen in the item "I hope that my future career will require the use of computing concepts" [14]. Overall, the findings showed participant changes from being "confused" to "able," then to "interesting," and at the end to "excited" [14].

2.4. Goal of this research project

This exploratory qualitative research study looked at preservice students' perceptions about their engagement with various technologies. This was done to determine whether emergent themes or patterns in their engagement could provide insights into preservice teachers' potential use in their elementary classrooms. This pre-Covid pandemic study could shed light on implementations in the Covid-19 pandemic virtual classroom and on post-pandemic learning in the classroom. The research questions that guided the study were: What are students' perceptions of their own capabilities and preferences for the technology? What themes and patterns emerge in students' engagement with the various instructional technology? What patterns emerge in students' connections to subject content matter and ideas about teaching and learning?

3. Methodology

3.1. Participants and course overview

Participants were undergraduate preservice elementary education majors enrolled in a required online instructional technology course in an Historically Black College and University (HBCU). Ten (10) students signed consent forms with IRB approval providing permission to use course artefacts. This overview highlights some of the lessons from this instructional technology course. The course began with an introduction to technology use within the elementary school setting, and a look at international and state technology standards. The goal of this introduction was to familiarize students with what more progressive schools were doing in technology and to encourage buy-in for the rest of the course. Students were encouraged to reflect on what they hoped to accomplish in the course and to consider advantages and disadvantages of technology in the classroom. In the next lesson students were introduced to GIS technology for learning using ArcGIS maps [15] and other geospatial technology. ArcGIS contained accompanying lessons, elementary "geoinquiries" [15] written using a 5E lesson format. Then students were asked to explore NASA's Eyes which is an interactive visualization software [16]. They were to create a lesson using NASA's Eyes. Students were then encouraged to reflect on the benefits and understandings gained from using geospatial technologies for learning in the discussion board. Next, students were introduced to coding technology. First, they explored Scratch coding using a pre-made 10 step direction lesson from the website and then they created their own scratch project. Then they used the code.org platform and carried out the checklist of activities. Next, they explored two types of simulations and interactive explorations, Phet Simulations and then, an interactive exploration from the Genetic Science Learning Center. They were encouraged to explore first without and then with the guiding questions provided. Other lessons included the use of Snap Circuits and Engineering Design activity to create a lunar lander. Students reflected on each implementation experience in the online discussion board.

3.2. Data collection

Data collection included students' online discussions for each topic. They responded to discussion prompts and to each other's postings. Since this was an online course, Blackboard was the main platform used. Students also answered pre and post questions for each lesson topic. These questions were grouped into three main categories related to their general perceptions about their own capabilities, overall preferences for the instructional technology, and perceptions about the tasks performed.

The pre and post questions were informed by Hatlevik and Hatlevik [17] research on the various relationships in teachers' use of Information and Communication Technology (ICT). Hatlevik and Hatlevik [17] collected data from 1158 teachers at 116 Norwegian schools to study associations between teachers' self-efficacy for using ICT for instructional purposes, and the impact and associations with "lack of facilitation by school management," [17], collegial collaboration and teachers' general ICT self-efficacy. Hatlevik and Hatlevik [17] used response categories such as: "1 = Never, 2 = Sometimes and 3 = Often" to look at ICT at school and categories "1 = I do not think I could do this, 2 = I could work out how to do this and 3 = I know how to do this" to look at "general ICT self-efficacy" [17]. Likert categories "1 = strongly disagree, 2 = disagree, 3 = agree and 4 = strongly agree" [17] were used to gauge teachers' beliefs about their ability to prepare lessons, monitor students' progress, and assess student learning. Similarly, these categories were used to inform the questions in this study, with modifications.

It is important to note that while Likert scale questions were used, this is a qualitative exploratory study, and not a quantitative research study. The Likert scale questionnaires were used to provide insights into students' perceptions and to enhance the qualitative narrative and vice versa.

3.2.1. General perceptions about capabilities using technology

At the beginning and end of the course the preservice teachers were asked about their general perceptions about their overall computer skills using questions such as: I have excellent basic computer skills. I feel confident about my basic computer skills. I can integrate technologies into lessons. I feel confident about integrating technology into education. Response categories ranged from 1 = strongly disagree to 4 = strongly agree.

3.2.2. Overall preferences for instructional technology

At the end of the course the preservice teachers ranked and provided explanations for their preferences for the tasks with 1 indicating highest preference and 11 indicating the lowest preference. They also ranked the technologies from least to most challenging, with 1 for least challenging and 11 for most challenging. They ranked technologies according to which they felt most comfortable implementing in the classroom, with 1 for most comfortable and 11 for least comfortable. Analyses sought patterns in rankings which were triangulated with their explanations and discussions.

3.2.3. Perceptions of individual tasks

To better understand preservice teachers as learners, they were asked about their experiences learning each technology and how often they observed its use in elementary schools. Pre and post questions asked how they felt about their own capabilities to implement them, prepare a lesson, and monitor students using each technology. Post questions were specific to each task and required students to provide explanations. For example, students were asked to: (a) *Reflect on your experience with geospatial technology, ESRI and NASA's Eyes, how would you describe your experience (s)?* (b) *To what extent do you think carrying out the lesson in ESRI helped you to create lessons in NASA's eyes?* (a) *What challenges did you have using NASA's Eyes?* (b) *What could you or the instructor have done differently to help you with this process? Please be as specific as possible.* For coding, students were additionally asked whether they preferred scratch or code.org and to explain why.

Survey questions specific to each task included: When did you observe coding in the elementary classroom during your student observations? How do you feel about your own capability to learn coding? How do you feel about your own capabilities to implement coding in the elementary classroom? How well do you feel about your capability to prepare lessons using coding technologies? All questions used a three tier Likert scale. Questions that asked how often used the scale: (1) Never; (2) Sometimes; (3) Often. The remaining questions used categories: (1) I do not think I could do this; (2) I could work out how to do this; (3) I know how to do this. Analyses sought patterns and correspondence in students' Likert scale responses and the explanations they provided.

3.3. Data analysis

Data analysis used basic statistics to examine the Likert pre and post questions to gauge changes in students' perspectives. Only the means and standard deviations for students who completed both pre and post questionnaires were used. Thus, not all data were used. The basic statistics do not provide reliable or generalizable data but rather triangulates the qualitative data and situates this very small sample in a larger context, should this be done on a larger scale. Discussions for students who consented were organized into conceptual ordered tables [18] and then uploaded into NVivo data analysis software. Data were coded for emergent themes using different types of codes. Simultaneous coding was used. According to Saldaña [19] simultaneous coding refers to the use of two or more different codes for the same data unit [19]. Codes were informed by the research questions and the literature, and analytic memos were used to generate codes for data that provided similarity or differences in meanings. Codes were also informed by research on schema theory to explore connections to learning and transfer.

3.4. Theoretical framework

Schema theory was used to explain the emergent codes and themes generated. Schema theory is a theory of remembering used predominantly in Mathematics to explain how students organize new knowledge in light of their prior learning and experiences [20]. Marshall [20] created a unique way of analyzing schema that encouraged flexibility in understanding student learning. According to Marshall "a schema is a vehicle of memory, allowing organization of an individual's similar experiences in such a way that the individual can easily recognize additional experiences that are similar, discriminating between those that are dissimilar" [20]. According to Marshall an individual's schema possesses form (architectural features) and substance (psychological features). The form of a schema refers to its *storage, networks, connectivity, flexibility, variability in size*, and *embeddedness*. The psychological features of schemata include the *construction* of the schema, what is given *attention to, repetitions, uniqueness, abstractions*, and *content variability* [20].

Quinlan [21–23] has used schema theory extensively to analyze and explain student learning for example, during discussions requiring multimedia data [22]. Similarly, Quinlan [23] used these features to look at the extent of transfer of learning to students' final assignments. However, in this particular study, schema is used mainly to inform and explain the repetitious and simultaneous codes generated rather than to generate codes.

3.5. Limitations

Not all students filled out both pre and post questions for each topic, so these numbers varied. The Likert scale results are not statistically significant nor generalizable but are used to triangulate the narratives in this exploratory qualitative research study. The discussion narratives were coded for emergent themes rather than look at individual cases where narratives triangulated with the survey. The results looked at overall perceptions and did not account for repetitions by individuals for different tasks. Therefore, it is possible that one or a few students' ideas were used repeatedly in the narratives. Effort was made to ensure that the narratives reflected different students.

4. Findings

This section consists of two parts. The first part looks at the results from the pre and post questions. The second part looks at emergent themes from students' discussions.

4.1. Results from pre and post questions

4.1.1. Overall preferences for instructional technology

Eight out of ten students highlighted their overall preferences for the instructional technology. Due to the number of tasks, the findings focus on the most preferred. The numbers in parentheses show how many students ranked the task as first and second in preference respectively—Inspiration (2,1); Code.org (2,1); Scratch Coding (2,1); Snap Circuits (1,1); Simulations and Interactive Explorations (1,1); and NASA's Eyes (0,1). Overall students' preferences corresponded with what they felt more at ease at implementing in the classroom, with some correspondence to which they felt least challenging. Most students highlighted their enjoyment and perceptions of usefulness in the classroom, followed by an opportunity to be creative. Only one student highlighted the Inspiration software in the narrative:

> I really enjoyed the inspiration software. My reason for this is because the different activities that were presented in this software could serve as study tools for the students. I really liked how students could map, put their thinking with the mind maps and show their creativity also. There were mind maps that allowed students to define words, recall information from a text, compare and contrast and even to assess a students' prior knowledge. I feel very confident in incorporating this technology into my classroom as I believe it can be very beneficial to the students (Ebony).

Another highlighted snap circuits: "I personally preferred snap circuits because it got me intrigued and excited to learn, and I know that if it can do that for me then it can definitely do that for my students. Creating the website was my least favorite because using Google lacks creative freedom" (Angel).

Table 1. Perceptions about capabilities for individual tasks (provided for comparison and not for statistical significance due to sample size).

	How well do you feel about your capability to prepare lessons using *X*?			How do you feel about your own capabilities to implement *X* in the elementary classroom?			How well do you feel you will be able to monitor your future students' progress using *X* technologies?		
	Pre M	Post M	SD	Pre M	Post M	SD	Pre M	Post M	SD
Coding	1.7 ($n = 8$)	2.6 ($n = 5$)	−0.6 ($n = 5$)	1.75 ($n = 8$)	2.6 ($n = 5$)	−0.6 ($n = 5$)	—	2.6 ($n = 5$)	—
Simulations	2 ($n = 5$)	2.5 ($n = 9$)	0.8 ($n = 5$)	—	2.5 ($n = 9$)	—	2.0 ($n = 5$)	2.1 ($n = 9$)	0.2 ($n = 5$)
Engineering	1.7 ($n = 9$)	2.3 ($n = 3$)	0.3 ($n = 3$)	—	2.6 ($n = 3$)	—	1.6 ($n = 9$)	2.3 ($n = 3$)	0.3 ($n = 3$)
Snap circuits	2.0 ($n = 3$)	2.8 ($n = 8$)	0.5 ($n = 2$)		2.8 ($n = 8$)		2.0 ($n = 3$)	2.5 ($n = 8$)	1.0 ($n = 2$)
SC with science content		2.6 ($n = 8$)							

In another example, Trinity said: "I really liked the projects where I got the chance to be interactive and creative, but some of them like the GIS seemed a little more abstract so I wasn't as interested, but I still think they would serve as great supplements to the classroom." There was one exception where Jasmine highlighted the importance of ease of use. Jasmine was the only one to highlight Scratch in her explanation: "Scratch was easiest to understand." However, she selected "creating a website" as her preference. It is important to note that she began her easiest ranking at 4 rather than 1.

4.1.2. Perceptions of individual tasks

Overall, students' responses to questions specific to each task showed that 88 out of 127 (69%) of the time they felt that they were capable of learning and working things out. In 34 out of 127 (26%) of the time they didn't feel they could do it, and for 3% (5 out of 127) of the time they felt that they actually knew how to do this. In terms of individual tasks, Geospatial technology was the only technology that students indicated they had observed in an elementary class often (2 out of 7); 5 out of 7 indicated they observed it sometimes. All students indicated that they never observed snap circuits during their elementary observations. For engineering, 6(0.67) indicated they "never" observed this in the classroom, and 3(0.33) indicated they did so sometimes (see Table 1).

Enjoyment of ESRI and NASA's Eyes was student specific. The one thing students agreed on was that this was a learning experience for them. One preservice teacher indicated: "I had an amazing experience … I was able to easily navigate through the maps and the solar system learning and reviewing facts about various topic … the only real challenge I had with NASA's Eyes was using the advanced mode." Another student's response seemed to suggest that she would have preferred not to be engaged in or be as involved with the tasks: "My experience with geospatial technology is that it was very complicated to use ... I believe it would [have] been more effective just as a video ... I would have like[d] more to watch a documentary or video of sorts." Generally, students agreed that they learned a great deal and that this was new to them. They also felt that the 5E templates in ESRI's geoinquiries lesson plans helped them create a 5E lesson for NASA's eyes.

However, preferences for ESRI versus NASA's Eyes seemed to go hand in hand with how they felt about exploring the technologies, or what they described as the need to experiment with the software or use them to learn science. Two students explicitly indicated they enjoyed NASA's Eyes more:

> I personally liked the NASA's Eyes software because it was more fun to engage ... I enjoyed the extra facts the NASA software included and this website was more of an explore by yourself activity. When it came to the ESRI technology I liked it. It was very detailed and left no room for students to really do things without so many instructions. Being that ESRI was so strict, this was a pro and con to me. I like that ESRI definitely helped me carry out a lesson plan in NASA's Eyes because I knew what instruction was needed to carry out a lesson plan in NASA's Eyes.

Students also shared their aha moments and insights in their responses. One student indicated the following:

> I like science and then I don't like science. I'm usually a bit anxious when I hear either science or technology so both of the words combined have me on the nervous side ... NASA's Eyes was my absolute favorite because I love outer space themed things. I love the nostalgia of outer space and I felt like I got to get a close in look. Not only that, I can go on it whenever I like!:). Everything in ESRI was a platform for creating the lesson plan. It gave me insight on how to make a science kind of lesson plan since I [am] used to creating lesson plans that are in relation to literacy and writing.

Some of their reflections reveal their own meta-level thinking about their learning. One response was especially enlightening when it came to how the preservice teachers felt about their experiences:

> I really liked working with both forms of technology. I thought they were interesting and a great tool that I could use in my classroom.

> I especially appreciated that they were free and open to public use. I thought it was confusing at first and that the introduction to the technology could have been better but I very much so felt like an expert after working with it. I think that the work in ESRI served as a great model for developing a STEM lesson plan. I felt that the ESRI could've used a little more background information in their lesson plan and a little more dialogue for teachers to use as a guide but otherwise I found it very efficient … I didn't realize how many components there were to NASA's Eyes until after I read some of the other lesson plans (i.e. looking at specific regions or time frames). I think that the challenges I faced came from me not exploring the site fully before I began working on my lesson plan. The professor did a great job of introducing the topic.

The preservice teachers reflected on how they felt their future students would do in comparison to what challenge they themselves had.

Overall, most students preferred code.org over Scratch because of the focus and connection to games, the different levels that catered to students, and the detailed instructions. The exception was one student who indicated her preference for Scratch. However, she was careful to separate herself as a learner versus a teacher in her choice:

> I enjoyed both of them a lot. It was a lot of trial and error as far as trying to figure out how to get the program to do what you wanted it to do, but that was all a part of the fun. I think I would use code.org in my classroom more so than scratch if I was trying to have the students code. It has lessons and units already ready to teach, and they made it simplistic enough for the students to be able to teach themselves. I would use scratch if I wanted them to complete an assignment I created because scratch gives coders a lot more freedom to create.
>
> Personally, I prefer scratch for myself as a coder, because it allows for more creative freedom. There are many code blocks to choose from, and rather than trying to complete an assignment like with code.org, scratch allows me to make any kind of video or game that I want. However, I do like code.org for instructional purposes.

She separated herself as a learner from her teaching role. Others seemed more focused on their role as a teacher. Alternatively, their role as future elementary teachers seemed to indicate whether or not they would enjoy the instructional technology. In some cases, they seemed to assume that their own experiences would be indicative of their future students' experiences. However, some were able to separate the instructional role from their learner role.

Table 2. Means and standard deviations for general perceptions about technology (provided for comparison and not for statistical significance due to sample size).

n = 6	Pre M	Post M	SD
I have excellent basic computer skills	3.83	4.3	0.50
I feel confident about my basic computer skills	3.66	4.5	0.83
I can integrate technologies into lessons	3.66	4.5	0.83
I feel confident about integrating technology into education	3.66	4.66	1.00

4.1.3. Feelings about preparing, implementing, and monitoring

Overall, students felt better about their ability to prepare and implement lessons, as well as monitor students' progress after they experienced the activities, with some exceptions, where students displayed no change (see Table 2). The preservice teachers felt better about preparing lessons using simulations and engineering design than they did about monitoring their students' progress in each of them. The opposite was true for snap circuits which was more hands-on. Both of the preservice teachers in this sample felt good about monitoring the activity. This could be explained by the arrangement of the tasks in the snap circuit kits, where easier tasks appeared first followed by medium and then challenging tasks. The preservice teachers were asked to choose tasks from each section—easy, medium, challenging. They seemed to enjoy the hands-on nature of the activities.

Concerning engineering, one student indicated that: "This unit was very interesting and I think a lot of students would really enjoy it if more schools implemented them into lessons and school curriculum. It actually encouraged me to think outside the box and use critical thinking skills. I also enjoyed it because it was a hands-on activity." Another noted that:

> I enjoyed the engineering design unit. This was something new to me as well. There has never been a time when I created a engineering design, so at first I was uncertain. However, I thought creatively and enjoyed this because I was capable to complete the assignment with flying colors. It was great and useful, this would be a project that I would love to do with my students. This would open many doors for students who think they don't have the ability to engineer and push them to try new things.

Students displayed connections with their feelings of enjoyment, thinking, and hands-on experiences. They highlighted how they felt about their likelihood to use this in their future classrooms.

Concerning snap circuits, students seemed to feel as if they were developing skills: "The snap circuits assignment was great. I enjoyed it and [found] the skills learned very useful. Being able to physically do the snap circuits was my favorite part of the lesson and I am more knowledgeable now in this area." Another indicated that "I really enjoyed the lesson. I had fun using the snap circuit. Thank you for recommending. I purchased it."

4.2. Emergent themes in students' discussions

This section highlights the emergent themes from students' discussions. The results were from tasks that explicitly encouraged students to reflect and from tasks where other ideas emerged. This section was arranged in order of frequency of occurrence with the most important themes presented first. The connections to the themes and frameworks are shown in bold and italics.

4.2.1. Perspectives about their own engagement

The preservice students' *perspectives about their own engagement* gave *attention* to whether they thought they might be able to use it in their future classroom: "I enjoyed these articles because it gave me more insights into ways to implement technology." Students paid attention to the potential to be a tool for the teacher. This student continued by noting: "Allowing students to have a clear visual map of what they are learning as well as an interactive aspect gives them the opportunity to fully understand what they are learning."

Some students' *perspectives about their own engagement* appeared alongside the *connections* they made and their *abstractions* from personal experiences: "Because this was my first time using the snap circuits I actually learned a lot myself and was very entertained with the activity. I would definitely use this in my classroom." In another coded segment one student stated:

> When I was creating these different projects, I was thinking of examples of the project in my real life. For example, when I was done creating project 3, I immediately thought of a doorbell. The way the sound in project 3 is activated by a tap is the same concept of a doorbell. This revelation made this activity so much more exciting for me because I was able to recreate the various currents of electricity just like the ones around me. I felt like a scientist or something and I can only imagine how this could be for students.

Overall, students' *perceptions about their own engagement* seemed attached to their perspectives about potential use for elementary students' learning, the ease at which they were able to implement the activity, and their feelings of enjoyment of the task.

There were other expressions of *perceptions about their own engagement* such as "I also enjoyed the use of mathematics as another way to find the exact distance with the use of the distance formula," and "I was very engaged in this lesson and realized that in my region there was a lot of oil, natural gas, coal, and gold found and farming and manufacturing are ways that the land is used." Lastly, one student noted that:

> It was interesting to learn the different power points that gave different states of electricity. Overall, I loved how detailed each lesson was and how easy it was to navigate without the presence of an actual teacher. The lessons were very detailed and I found myself actually learning new information but also reflecting on some things that I was also taught.

Thus, preservice students' feelings about learning were *connected* to their future role as a teacher, the importance of hands-on experiences, and whether the activity was interesting to them.

4.2.2. Benefits to elementary students

Students' perceptions about the potential benefits to their future students were generally related to the *opportunity to learn*, the *hands-on*, *visual*, and *interactive* experiences they provided. Some pointed to the *nature of specific knowledge* that students would *improve* in such as, "complex subjects like social studies and science. I love the idea that they used maps as a hands-on way of learning." Another highlighted the basic understandings and student-centered learning: "Making an activity student-centered can help us as future teachers get our students more deeply engaged in the content, and it can promote the kind of deeper learning … Students get a chance to learn geography, history, and maybe even culture." Another highlighted her experience with the *Mathematics* but connected it to children: "This activity could be a great tool to use in real life situations so that children can have ways to measure and calculate their distance from place to place. Also, children can see the distance where they live in places that they themselves may want to explore."

Students pointed to the nature of *procedural knowledge* that students would engage in such as, "I would definitely use this lesson in my classroom. It is an amazing way to teach students how electricity works because they are creating it themselves. The way the projects are numbered allows students to gradually become exposed to electricity and how it works." A student indicated in response to another's posting: "I felt like completing 1–10 would be beneficial for elementary school students. However, once they got harder like 20 and up it was hard to complete and follow. It began to add to many elements. However, 1–10 would be great for teaching elementary school students about electricity and how it works." Another talked about the potential to "transform learning for disadvantaged" when she read about a teacher who introduced it to a school in South Africa. Overall, the importance of connecting to students' "real-life experiences" was a recurring theme.

Overall, students had very strong opinions about implementing technology. These feelings/perceptions went hand in hand with their own feelings about implementing it as a teacher. One student stated: "As of right now, I would like to include technology in my classroom, however, I feel that it will be challenging to integrate it in a way that would be certain to benefit most if not all of my students … I want them to be able to use technology as not only a tool for learning, but also as a fun class activity." Another noted that "I don't want my students to feel as though computers are only meant for traditional work and classroom learning. I would like my students to see that technology can be used to stimulate the mind, while at the same time giving them a break from regular classroom learning." Similarly, another noted that "after exploring the GIS technology I felt more comfortable using technology in a classroom setting because it's more than a game but an essential tool to help students get engaged and learn quicker." Lastly, another student indicated that "As an elementary teacher, I see myself using technology to engage my students and to provide learning experiences for not only my students but also for myself."

4.2.3. Perspectives about personal prior experiences

Students' *personal experiences*, *positive feelings/perceptions about the activity*, and *negative feelings/perceptions about the activity* were important in their discussions. The preservice students described their own prior experiences as a K-12 student when they observed their own teachers: "As for technology, throughout elementary school I watched many teachers struggle to use the new technology they wanted to incorporate." One student noted: "In elementary school, I barely even saw a map. Once in a blue moon my teacher would pull down the map in our class and point to certain states she was talking about. However, this website provides a very detailed and organized journey of learning through maps." Another student responded: "I like how you brought up how teachers rarely even pulled out the map to show the class. In my class, we barely looked at maps hands-on because of the lack of resources."

Students talked about their mastery experiences with technology: "As I see technology grow, I am already struggling to keep up. I've always struggled with using technology in every aspect. Sophomore year of high school, I took a web design class and failed because I was so behind on basic technology." Another student connected the GIS map activity to her personal experiences:

> I did the street maps activity as well, and I really liked the 'explain' section as well. I enjoyed the website showing students how to use the map to calculate what time they have to wake up and get to school on time because that would have been very beneficial for me when I was younger. I've had to walk to school since I was in kindergarten as well as many other 'latch-key kids'.

Students also discussed their teachers using television for educational programs or episodes related to what they were learning or for behavior modification: "I have also seen teachers use music as a way of alerting children of when they should be transitioning between activities throughout the day." Another noted that "In my experience with learning with technology, as a kid I didn't find it was too helpful … Teachers used the TV as a way of getting us to behave well. The good kids got to watch the movie on the carpet after they finished their work and the bad kids who didn't, weren't able to … As a kid, I didn't find the use of technology as beneficial but as technology had progressed, I think that it has become a necessary tool."

5. Discussion and implications

5.1. Transfer

While this data for this exploratory qualitative research was collected prior to the Covid-pandemic, unpacking the role of technology before the onset of the pandemic, both in the K-12 classroom and in the preservice instructional technology course, is important in understanding the onset of learning using technology during and after the Covid-pandemic. All teachers were expected to transfer their skills as in-person classroom teachers to the new mode of teaching that required different types of expertise in instructional technology. Some were successful and others were not so successful. Bransford *et al.* [13] note that "knowledge that is overly contextualized can reduce transfer; abstract representations of knowledge can help promote transfer" [13]. This leads us to wonder what knowledge about instructional technology leads to the most effective transfer of skills from the physical to the virtual K-12 classroom. While Albion's [24] literature review show that self-efficacy beliefs are important indicators for how prepared teachers are to implement technology, Albion points to the greater challenge for teachers with more traditional views compared with those with more student-centered views. According to Bransford *et al.* [13] transfer is an active and dynamic process and not a passive one and depends on an individual's initial learning. This supports the need to consider both preservice students' and in-service teachers' prior experiences with technology and hence their prior schemas. As this study shows, preservice students abstracted from prior experiences as far back as elementary school. They abstracted from vicarious experiences when they observed their own teachers use technology for behavior management. They discriminated between the use of technology to learn or for other purposes.

However, while preservice teachers highlighted their own engagements during the activities and discussions, their perceptions about their own capabilities and preferences at the end of the activity tells another story in their post responses. Their initial discussion was consistent with what they gave *attention* to and were influenced by in the task. They *abstracted* from what was incongruent with their new experiences. Thus, *repetitions* in their experiences are important for effective use of instructional technology, to help them develop *flexibility*, build a schema, and develop "abstract representations" [13] related to technology implementation. Transfer takes time. The teacher in Dickes *et al.* [12] study moved from observing the researchers implement to equal co-designing, then to lead instructor and then to sole instructor of her class. Transfer is indicated in her development of agency and her perceptions of the usefulness to students.

5.2. Overall preferences for instructional technology

This need for *repeated* meaningful experiences with technology is underscored by the findings on students' preferences. When asked about overall preference for instructional technology preservice teachers more easily aligned their responses to their role as a teacher than their role as a learner. Among their preferences were Inspiration, Coding, Scratch, Snap Circuits, and Simulations. Overall, their preferences seemed to correspond more to whether or not they saw themselves using it in the classroom than whether or not they felt it was easier to learn. The findings underscore the importance of introducing prospective teachers to a variety of technologies and methods of integrating technology. Szeto and Cheng [25] looked at preservice primary and secondary teachers' patterns of integration of technology within different subject areas and found that all preservice teachers integrated Youtube across all subject areas. The other technologies their preservice teachers included were PowerPoint, ebooks, and CD/DVD. The frequent use of these technologies could be indicative of teachers' preferences, thus supporting the need for a wider experience.

5.3. Implications for the instructional technology course

That the instructional technology experiences of Black preservice undergraduate elementary education majors were negative while in elementary school should not be a total surprise. This expectation and observation, particularly for Black students informed the approach to this instructional technology course. The assumptions are supported by the research that shows that Black students' K-12 learning experiences is different from that of White students. Boykin and Noguera [26] point out that Black students are often left to work alone in isolation. Thus, the researcher began with the assumption that technology is often used a babysitting and behavior management tool particularly for Black students. This is supported by the preservice students' narratives about their own personal experiences. It is important to note that these personal experiences are emergent codes from students' reflections.

Instructional technology courses for elementary education majors should go beyond preparing teachers to use class organization platforms or video communications and conferencing platforms, which are school-specific, and which they could learn in professional development workshops with their school districts. Flick and Bell [27] recommend that technology be used to understand science rather than be decontextualized, to allow students to experience the unique features of the technology and to encourage inquiry. The use of technology to help students develop spatial learning is an important consideration [7, 8]. However, extreme caution should be taken to determine what this means for classrooms with predominantly Black students. Seemingly good intentions could easily replace instruction with video games which students could play on their own at home and which do not require a classroom teacher to monitor. Thus, with any good practice it is important to ask what this means for students of color and for implementations in classrooms with predominantly Black students.

5.4. Conclusion

Future studies should explore the prior technology experiences of both preservice and in-service teachers. Prior experiences influence teachers' preparedness to effectively use technology and can be indicators of potential use. Furthermore, considerations should be given to the implementations of standards and goals for learning to determine the extent to which effective use of technology is equitable, promote higher level thinking, or is used for behavior management with students of color.

This study is important in providing a frame of reference for the nature of thinking that might similarly influence today's education progressions using instructional technology both in the K-12 setting and beyond. With the current mobilizations of various platforms for learning during post-Covid pandemic, it is important to consider the extent to which best practices in learning and in instructional technology influences current trends and current saturations.

Conflict of interest

The authors declare no conflict of interest.

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