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Orchestrating the Multidisciplinary Implementation of a Narrative-Centered Learning Environment in Upper Elementary Classrooms

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Abstract: Integration of computational thinking (CT) within STEM subjects is common, although not often at the elementary school level where teachers have minimal experience with CT. We have designed and are refining a narrative-centered digital learning environment to support upper elementary students' CT and science knowledge as they create digital stories. We used orchestration as our theoretical framework, to examine how elementary teachers planned to approach this multidisciplinary implementation. Through a series of three focus groups, we learned that teachers planned for their students to take notes or utilize other graphic organizers to align the science content with the narrative planning, to engage in collaborative sense-making, and to observe the teacher modeling use of the InfuseCS system. Ultimately, the results have informed the next phase of our research design as we collect teacher and student level data as InfuseCS is utilized in authentic classroom settings.

Introduction

Researchers and practitioners increasingly acknowledge the importance of computational thinking (CT) in supporting students' problem-solving skills across learning contexts and subject areas (Yadav et al., 2016). Although the integration of CT among other academic disciplines is both practical and effective (Voogt et al., 2015), this integration is complex at the elementary school level as US teachers have minimal experience with CT (Code.org Advocacy Coalition, 2018). The overlap between CT and STEM subjects (Basu et al., 2016) supports the integration within such subjects. Many elementary teachers incorporate reading, writing, and discussion practices into their daily teaching, making it a feasible space to integrate CT; however, there are fewer findings around how to blend CT and language arts. As such, deep multidisciplinary work, designed specifically for elementary contexts, can help us better understand how to integrate CT into these grade levels.

We have designed and are iterating upon a narrative-centered digital learning environment that utilizes a block-based programming language to foster upper elementary students' (ages 8 to 11) CT and science knowledge construction as they create digital stories. Digital storytelling permits the creation of effective and engaging learning experiences that support diverse individual needs (Smeda et al., 2014), including learning science concepts in elementary grades (Smith et al., 2020). It also helps teachers weave CT into elementary settings without requiring the need for separate courses. What is not yet known is how elementary teachers approach such multidisciplinary implementations that integrate CT, science, and language arts.

Theoretical Framework

Orchestration has been proposed by educational technology researchers as a useful heuristic for understanding how teachers facilitate technology-enhanced learning environments to support student learning experiences (Dillenbourg et al., 2018). The framework supports understanding of how novel instructional technologies are implemented in the classroom by acknowledging the integral role of the teacher as they manage the complexity of these environments and their students' varied learning needs (Dillenbourg, 2013). We recognize that central to the technology integration process are the decisions that teachers make with regards to planning and designing for the optimal use of technology to meet intended learning objectives, as well as the adaptations and modifications made as those technologies are used by students in real-time (Roschelle et al., 2013).

The orchestration process for technology-enhanced learning environments often unfolds with developers initially designing curricula and resources for teacher and student use (Kollar & Fischer, 2013). Teachers then adapt the designed curriculum to fit their classroom constraints and contexts. The ways teachers intend to modify the curriculum can help researchers and developers be more efficient and practical when designing new classroom learning technologies (Wang et al., 2018).

Methods

Data collection

We conducted a series of three focus groups with elementary school teachers during the spring and summer of 2021. In the spring of 2021, two focus groups were held, each with three participating teachers. These 75-minute focus groups were conducted virtually and recorded with video conferencing software. All video sessions were transcribed verbatim. We utilized a semi-structured protocol that consisted of three parts: 1) an introduction to the learning environment; 2) teacher experimentation with the learning environment; and 3) post-experimentation focus group questions. During the experimentation phase, the participants individually joined a breakout room, shared their screens, and engaged in a think-aloud interaction with the learning environment. An example probe included, “What did you learn today that will help you teach InfuseCS curricular materials and use the learning environment?” The final focus group occurred at the conclusion of an eight-hour summer workshop on InfuseCS. The participants from this final focus group were asked questions such as, “Where do you see InfuseCS best fitting into your curriculum and what you already teach?”

The InfuseCS learning environment

The InfuseCS learning environment has two components: 1) a Science Explorer where students learn about energy sources and conversion via multimedia content and a simulation (Figure 1); 2) a Narrative Designer where students develop interactive stories using a block-based programming language (Figure 2). The goal is for students to integrate scientific understanding as they solve a problem-based learning scenario (e.g., shipwrecked scientists on a deserted island must power up their village) depicted through their narrative.

Figure 1

Screenshot from Science Explorer

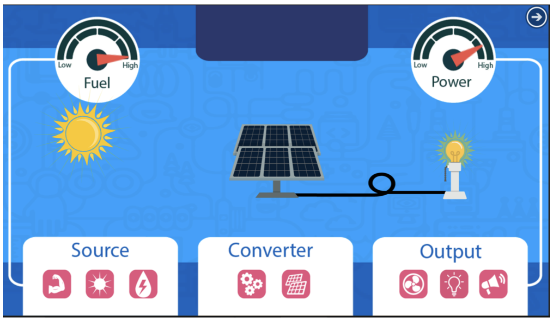

Figure 2

Screenshot from Narrative Designer

Data Analysis

Three researchers individually open coded the transcripts from each of the sessions. The researchers focused on thematic elements related to how teachers planned to implement InfuseCS with students. Subsequently, the researchers met collectively to determine where their identified themes converged across the sessions and reached consensus on the thematic elements of the results. The thematic findings highlight our teacher participants’ perspectives on how they intend to implement and adapt InfuseCS for their students’ benefit. Such orchestration efforts reflect their understanding of the complex physical and digital learning environments in their classrooms.

Findings

Strategies for Connecting Science to the Problem Scenario

Teachers were concerned with how well their students would connect and integrate the science concepts and ideas presented within the Science Explorer into their narratives. Such disciplinary literacy highlights the need to read and write well across the content areas. The teachers suggested two ways this could be supported throughout the learning experience. First, teachers commented that they would encourage their students to take notes on key science concepts presented to them throughout the Science Explorer. One teacher advised that, “All the vocabulary that you know [the students] are going to need [should be] accented in some manner and having them be able to take some notes… on paper and pencil or putting a little notepad on the screen.”

Second, teachers noted that students would benefit from using a storyboarding process with graphic organizers for notetaking and planning of their stories. This strategy would simultaneously scaffold the integration of science concepts from the Science Explorer into their narratives. One teacher mentioned, “If you want them to write a story on a deserted island with all of the science concepts that they've just learned, you have to tell them that, and having a piece for them to pre-organize themselves, you have to do that for them.”

Collaboration and Discussion for Sense-making

All teachers noted the potential that collaborative discussion—a CT skill—could offer for fostering successful student experiences with InfuseCS. They shared ideas of how they would embed collaborative opportunities to facilitate the sense-making process (e.g., whole-class, small group, dyads), and where in the learning process it would best occur (e.g., interactions with the Science Explorer, planning their stories). In describing the utility of peer collaboration in small groups for connecting the science concepts to the story building process, one teacher commented that small group collaboration would be beneficial for ideation, noting, “I just think they’d need to work either in pairs or in a group to come up with some ideas first and then put it in [their narratives].”

Other teachers noted that whole-group discussion would stimulate brainstorming and connecting the ideas from the Science Explorer to the problem-based scenario. One teacher suggested prompting discussion with *If you were on an island, what could you do?* so all students could think through and discuss different responses before encountering the science concepts and writing their narratives. Others suggested going through the Science Explorer as a class and discussing the scientific concepts as they appeared could help to mitigate potential misconceptions and stimulate the process of scientific inquiry.

Teacher Modeling and Pacing

Due to the unfamiliarity of the learning environment for students, as well as the novel approach to generating science-rich narratives that it supports, teachers felt strongly that some degree of teacher modeling throughout the *entire* learning experience was necessary. This finding was somewhat in contrast to what we anticipated. We believed that teachers would primarily be interested in demonstrating the Narrative Designer portion to alleviate their stated concerns about students who would not have prior experience with a block-based programming environment. However, teachers offered ideas for teacher modeling during all the system’s learning components. One commented, “I would want to go through it with my students, so they really got it. Then if there were other ones that they did later, they would get the whole process.”

Further, teachers offered valuable insight into how they would pace the instruction and student exploration of the InfuseCS learning environment for optimal learning outcomes. The teachers believed that by demonstrating the learning environment first for students as a class, the time needed for students to get accustomed to the system would decrease. As such, several teachers noted the need to plan for more time at the outset of using InfuseCS. One commented, “Anytime you use something for the first time, it takes you three days to get through it. The next time, it's not going to be as much.”

To create an optimal learning experience for her students, one teacher noted how she would balance and pace different instructional strategies throughout the various components of the InfuseCS system:

> “I could see teaching each of the [energy] sources, showing it in [InfuseCS], working through the slow process of how does it work, doing it in here, then playing with it, and then simultaneously, we're also starting to create that storyboard … [in] small groups … Then their final project would then be to do it themselves.”

Discussion, Conclusion, and Future Directions

Our thematic findings indicate that, even with limited background in teaching CT and block-based programming, elementary school teachers have clear and pragmatic intentions for how they propose to implement a narrative-centered problem-based digital learning system such as InfuseCS in their classrooms. Using orchestration as a guide, we highlighted from our three teacher focus groups the ways teachers indicated they planned to modify and ultimately implement InfuseCS for the benefit of student learning outcomes.

This work foregrounds that regardless of the specific educational technology, the role of the teacher is instrumental in shaping student learning experiences. Teachers possess deep expertise about their students' needs, as well as the cultural and contextual constraints in which these learning environments will be used. Acknowledging teachers' expertise in the classroom, we note that their desired modifications, what Kollar and Fisher (2013) call 'arranging,' in service of what is best for their students, bears out in the literature (Dillenbourg, 2013). Recall that teachers mentioned wanting their students to take notes or utilize other graphic organizers to align the science content with the narrative planning, to engage in collaborative sense-making, and to observe the teacher modeling use of the InfuseCS system. Listening to our teacher participants' suggested modifications will drive our research and development work moving forward.

Although InfuseCS was not explicitly designed for students to work together, teachers who create intentional opportunities for students to engage in collaborative learning throughout the scientific inquiry and narrative design process can increase student learning outcomes (Chen et al., 2018). Thus, we will document teachers' strategic use of collaborative learning with InfuseCS during implementation to determine its effectiveness. The teachers in our work noted an extensive amount of modeling they intended to utilize. Wood et al. (1976), the originators of the term *scaffolding* in education, suggest that the purpose of scaffolding is to control learners' frustration, guide learners' actions in support of their learning, and model the problem-solving process. We intend to assess teachers' varied levels of in-class scaffolding and students' learning outcomes.

Ultimately, we found orchestration, in particular documenting how teachers would "arrange" the use of InfuseCS in their classrooms, a helpful lens to plan future professional development and design support for teachers as they learn to integrate it in their classrooms. The results have also informed the next phase of our research as we collect teacher and student level data as InfuseCS is utilized in authentic classroom settings.

References

Basu, S., Biswas, G., Sengupta, P., Dickes, A., Kinnebrew, J. S., & Clark, D. (2016). Identifying middle school students' challenges in computational thinking-based science learning. *Research and Practice in Technology Enhanced Learning, 11*(1), 1-35.

Chen, J., Wang, M., Kirschner, P. A., & Tsai, C. C. (2018). The role of collaboration, computer use, learning environments, and supporting strategies in CSCL: A meta-analysis. *Review of Educational Research*, *88*(6), 799-843.

Code.org Advocacy Coalition. (2018). 2018 state of computer science education. https://code.org/files/2018_state_of_cs.pdf

Dillenbourg, P. (2013). Design for classroom orchestration. *Computers & Education, 69*, 485–492

Kollar, I., & Fischer, F. (2013). Orchestration is nothing without conducting–But arranging ties the two together!: A response to Dillenbourg (2011). *Computers & Education, 69*, 507-509.

Montrieux, H., Raes, A., & Schellens, T. (2017). 'The best app is the teacher' Introducing classroom scripts in technology-enhanced education. *Journal of Computer Assisted Learning, 33*(3), 267-281.

Roschelle, J., Dimitriadis, Y., & Hoppe, U. (2013). Classroom orchestration: synthesis. *Computers & Education, 69*, 523-526.

Smeda, N., Dakich, E., & Sharda, N. (2014). The effectiveness of digital storytelling in the classrooms: a comprehensive study. *Smart Learning Environments, 1*(1), 1-21.

Smith, A., Mott, B., Taylor, S., Hubbard Cheuoua, A., Minogue, J., Oliver, K., & Ringstaff, C. (2020, November). Toward a block-based programming approach to interactive storytelling for upper elementary students. In *International Conference on Interactive Digital Storytelling* (pp. 111-119). Springer, Cham.

Voogt, J., Fisser, P., Good, J., Mishra, P., & Yadav, A. (2015). Computational thinking in compulsory education: Towards an agenda for research and practice. *Education and Information Technologies, 20*(4), 715-728.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*(2), 89-100.

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

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