



Making Space for Visual Literacy in Literacy Teacher Preparation: Preservice Teachers Coding to Design Digital Books

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Abstract

To reduce the lag between highly visual texts in elementary classrooms and a lack of emphasis on visual literacy in teacher preparation, this study explored preservice teachers' coding in the design of a visually-enhanced digital book. A qualitative case study shaped the research design and data collection, including ten digital book artifacts and reflections from preservice teachers. Content analysis identified modes of communication evident within digital books, while thematic analysis examined reflections. One book included all modes of communication. Books lacked consistency of supportive, accessible, and engaging features such as narration, captions, and scene detail. Reflections indicated possibilities and visual affordances of digital book reading in the classroom, at the cost of technological challenges and time required to use a new tool. Findings call for a shift to acknowledge and incorporate visual literacy theories and practices into teacher preparation programs to prepare preservice teachers for digitally literate classrooms.

Keywords Coding · Educational technology · Higher education · Multimodal literacy theory · Preservice teachers · Visual literacy

Today's students use digital tools to narrate stories and engage in related visually-enhanced literacy experiences (Eutsler, 2019; Rowsell et al., 2012; Silverman & Piedmont, 2016). However, teacher preparation programs lag behind the rate at which classrooms consume visuals, particularly those which attune to digital reading experiences. In March 2021, an unrefined search of “visual literacy”, “teacher preparation” and “digital book” between 2010 and 2020 returned only 19 Google Scholar results that included nine scholarly articles, six books, two conference proceedings, and two dissertations. The paucity of research among these areas is concerning because visual supports aid students in comprehending digital texts (Dawson et al., 2021; Piotrowski & Krcmar, 2017).

John Debes coined the term “visual literacy” (VL) in 1969 (Avgerinou & Ericson, 1997), but its definitions have been in constant flux since its inception. According to *Visual Literacy Today*, a group of researchers, educators, designers, media specialists, and artists dedicated to visual design, visual

literacy is the ability to create and interpret visual images (Harrison, n.d.). This concept relates to art and design but has much wider applications because it also pertains to language, communication, and interaction. Visual media are linguistic tools with which we communicate, exchange ideas, and navigate the complex world. Applicable to this study, visual media includes images and videos (e.g., as shared on social media networks) in addition to viewing digital books on an electronic device.

Visual literacy includes the ability to communicate through multiple modes (e.g., digital, visual, spatial) and spaces, such as blogs, social media, and text messaging (Sanders & Albers, 2010). The *National Council of Teachers of English* has addressed the importance of integrating multiple modes of communication (, 2005). This involves teachers and students creating multiple meaning-making systems such as alphabetic, oral, and visual, that are codependent of one another (NCTE, 2005). However, these modes of communication are lacking attention within literacy teacher preparation, especially in connection with digital literacies. It is not surprising that teacher preparation programs are largely unaware of the differences when reading digital texts because teacher educators did not grow up reading digitally (Eutsler, 2018). Furthermore, the increasing adoption of digital texts in homes and schools (Eutsler & Trotter, 2020; Kabali et al., 2015) indicates the

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need to engage preservice teachers (PSTs) in practices that address multiple modes of communication and literacy.

Educator standards (e.g., CAEP, 2016; ILA, 2017; ISTE, 2019) also confirm that developing digital literacies is a curricular imperative for teacher educators. In response to increased uses of technology and attention to multiple modes of communication, PSTs require hands-on opportunities to engage in using the most readily available technology for educational purposes (Ciampa, 2017; Walsh & Farren, 2018). However, PSTs often simply learn *about* technology rather than engage with using technology to explore and plan instructional or learning experiences (Eutsler, 2021).

Attention is needed to address the design of digital literacy experiences for elementary learners. Research finds children as young as 3 and 4-years-old who selected a digital book over a print one participated longer in shared reading experiences (Eutsler et al., 2020).

The purpose of this study is to focus on modes of communication, to explore how Pre-Service Teachers implement Visual Literacy elements into their design of digital books. This study directly contributes to VL research in literacy teacher preparation because it asserts the need to carefully consider visual elements when reading digitally. The literature review includes: an overview of VL in education as well as within higher education and elementary classrooms; the evolution of digital book characteristics and features; and the use of technology in literacy teacher preparation. This research helps situate an understanding of multiple modes of communication that can be applied to support VL concepts when designing digital books.

Literature Review

Visual Literacy in Education

Since definitions have shifted over time, it is essential to define Visual Literacy in the current context. A more recent definition within the context of higher education, and one most applicable to this study, involves visual reading, visual writing, visual thinking, visual learning, and applied image use (Kędra, 2018). Some research has identified the benefits of combining VL with technology integration learning experiences. For example, when applying VL design principles, PSTs “produced work that was more usable and more professional looking” (Sosa, 2009, p. 57). In another iteration of VL in a teacher preparation program, PSTs produced accurate definitions and appropriately interpreted the visuals; researchers attributed these skills to direct instruction of VL in the course design (Yeh & Lohr, 2010).

A summary of a volume of research on Visual Literacy identified seven suggestions and strategies to support faculty with its integration: 1) careful consideration of how VL can

help students meet learning objectives; 2) alignment of assignments with course objectives; 3) consideration of novice versus expert proficiency levels; 4) scaffold assignments to help students develop expertise in their discipline; 5) model professional integrity and ethical and legal practices; 6) include as an ongoing teaching practice; and 7) disseminate VL created assignments to demonstrate learning (Little, 2015).

The growth of educational technologies and the variety of digital books available calls for the need to consider them as prime tools that facilitate vivid and enhanced reading experiences. Though some research has focused on VL in higher education, more research is needed in teacher preparation programs to equip preservice teachers with strategies to integrate VL concepts into multimodal literacies.

It is important to incorporate Visual Literacy concepts into teacher preparation programs because these experiences can help students comprehend text and develop their reading skills (Lundy & Stephens, 2015; Rowsell et al., 2012; Silverman & Piedmont, 2016). A curriculum analysis revealed curriculum standards for education referred only peripherally to the use of visuals. The study was based on the understanding that Visual Literacy includes perception, imagination and creation, conceptualization, and analysis (Vermeersch & Vandembroucke, 2015). An important consideration for integrating VL concepts into the curriculum is to acknowledge that students possess varying levels of visual skills. Teachers should assess students’ understanding of VL using “authentic texts, such as picture books, information books, electronic texts, and texts that students create” (Callow, 2008, p. 619). For instance, when 2nd-graders were shown picture books, children were aware of the pictures but lacked attention to the intentional visual devices used by illustrators (Prior et al., 2012). Research of students’ and teachers’ VL experiences draws attention to the benefits and importance of visual supports when reading, a justification VL should be threaded throughout teacher preparation programs.

Evolution of Digital Book Characteristics and Features

A focus on digital book characteristics and features can help identify multiple modes of communication afforded by reading digitally. Earlier research found that digital book features (e.g. hotspots) can be distracting (de Jong & Bus, 2003; Korat & Shamir, 2004). Since then, other research has shown how digital books can support comprehension with features like captions and audio narration, providing the reader with more accessibility to text (Eutsler et al., 2020; Piotrowski & Krcmar, 2017). The ability to integrate visual design principles into digital books is strengthened with the introduction of smartphones in 2007, the iPad in 2010, and the Chromebook in 2011. Additionally, the COVID-19 pandemic has prompted a concern in needing to ensure students have a device to access remote learning (Koehler & Farmer, 2020).

Despite ubiquitous adoption of mobile devices, digital books have been slow to evolve over the past few decades. For example, digital books have changed dramatically since they were first introduced on CD-ROM in 1985, known then as “expanded books” (GPO, 2014, para. 4). It was not until 1998 that U.S. libraries began allowing its users to check out eBooks (electronic books) to read on a web browser. In these initial stages of digital book design, readers were limited by the device and its functionality. Books could only be read on a website via computer and laptop. One of the earliest book designers was Storyline Online, developed by the Screen Actors Guild Foundation (IMDb, 2002). Intended for elementary readers and read-aloud by celebrities, students listened to the story, accompanied by captions, and viewed the pages, which included some character movement. Inside K-3 classrooms, many teachers incorporated a designated listening center where students followed along with a book on cassette tape or CD-ROM (Shamir & Korat, 2006) to improve their fluency skills.

Tablet development prompted an uptick in educational technology researchers’ design of digital books (e.g., Wang & Huang, 2015). With the retirement of cassette tapes and compact discs, researchers continued to investigate uses of the iPod (Liu et al., 2014), iPad, (Minshew & Anderson, 2015), and Chromebooks (Quinn, 2016) to support students’ literacy in the classroom.

Using Technology in Literacy Teacher Preparation

Pre-Service Teachers require “substantial professional development in selecting appropriate technologies and learning how to program so that they feel confident in using the tools on their own and in the classroom” (Ching et al., 2018, p. 569). Formal support of technology integration in teacher preparation is essential. However, despite young students’ success in improving their literacy skills with the aid of educational technology, some teachers still resist teaching with technology (D’Agostino et al., 2016). This highlights the need for teacher preparation programs to show preservice teachers how to integrate technology into their instruction (Eutsler, 2021; Watts-Taffe et al., 2003).

When planning to enhance PSTs’ educational technology skills, it is best to avoid assumptions about their skill level. Lei (2009) found while 55 PSTs were labeled as technologically literate, only about 10% used technology for educational purposes. Relatedly, Gasaymeh (2018) identified that undergraduate students primarily use technology to connect socially. Case study instances of PSTs using technology show the importance of facilitating low-risk, hands-on technology explorations, including mentoring support (Groth et al., 2007). An investigation of 1441 PSTs’ beliefs about integrating technology into literacy instruction revealed low-levels of technology integration and an emphasis on obstacles. In this study,

researchers concluded that PSTs’ stance toward technology is trumps their level of support (Hutchison & Reinking, 2011). In another study, 44 PSTs were asked to share their perceived ability to integrate technology into literacy lesson; their greatest challenges were pedagogical, relating to the management of the lesson activity and student engagement (Christ et al., 2019). Other researchers emphasize the benefit of allowing PSTs to explore a variety of technology programs, websites, and apps, which leads to improved pedagogical decision-making (Eutsler, 2021; McGee & Welsch, 2020).

With a constant influx of technology innovations, PSTs benefit from a structured and supportive approach to implement technology into instruction, one that develops their knowledge of the technology and is connected to the content and learning standards (Hutchison & Colwell, 2016). Fedon’s (2017) case study of PSTs’ arrived at multiple factors to consider when scaffolding technology integration experiences. For example, a) technology is often perceived as a substitution or engagement strategy, b) there is a perceived benefit to modeling technology use by influential instructors, and c) embrace preparedness and flexibility in the event of a technical failure. In Tondeur et al.’s (2012) review of PSTs’ preparedness to integrate educational technology, they emphasize the importance for teacher educators to serve as role models, engage students in authentic technology experiences, and provide institutional support.

Theoretical Framework

To better understand the modes of communication associated with the design of digital books, this study is grounded in multimodal literacy theory (Jewitt & Kress, 2003; Kress, 2010). Multimodal literacy theory considers the multiple methods of communication offered by a digital book—illustrations, written text, narration, character expressions and movement—and how the reader attempts to make sense of the story based on the book features. Text in isolation is deemphasized and additional modes of communication are considered, such as vivid, life-like illustrations and movement.

Visual, verbal, and gestural features provide students with additional reading clues and context beyond the written words and pictures (Jewitt & Kress, 2003). These visuals can improve student comprehension because “people learn more deeply from words and pictures than from words alone” (Mayer, 2009, p. 47). Life-like characteristics can help students engage in digital book reading because of colorful and interactive illustrations, while audio narration can guide the reader toward understanding the plot. Another visual advantage of reading a digital book is the option to view the book through a head-mounted virtual reality viewer, which can make reading a highly personalized and visually captivating experience.

An understanding of literacies and the ways in which literacy should be taught in teacher preparation programs continues to shift in response to new technologies and tools. This study explores how preservice teachers attend to multiple modes of communication after learning basic coding and designing a digital children's book.

Research Questions

1. What visual modes of communication do Pre-service Teachers code for and build into the design of their digital books?
2. How do Pre-service Teachers view their experience of coding and designing a digital book?

Method

This qualitative case study occurred within a bounded system because it took place within the context of one higher education classroom, and was classified as instrumental to gain insight into the visual book design process (Stake, 1995). Content analysis (Neuendorf, 2002) was used to examine each digital book artifact, to identify instances of each mode of communication. Reflective narratives were analyzed using thematic analysis (Braun & Clarke, 2006). Content analysis provides descriptive counts to reveal patterns among artifacts (e.g., images), whereas thematic analysis is a recursive process that identifies apparent themes within patterns of language.

Participants and Context

During spring 2020, research was conducted at a Hispanic and Minority-serving public university located in the southwestern region of the United States which enrolls approximately 38,000 students. Participants included 28 Pre-Service Teachers pursuing early/elementary teacher certification in an early childhood/elementary education reading methods course. All but one PST identified as female (96.43%), and most identified as white ($n = 19$, 67.86%) and Latinx ($n = 9$, 32.14%).

Procedures

To inform the design of their digital book, PSTs read an upper-elementary level chapter book together in a small group. Working with a partner or independently, they rewrote the book in their own words to an age-appropriate level of K-1. An asynchronous virtual workshop (15 min and 55 s) helped them become familiar with block-based coding and the digital book creation tool, CoSpaces Edu (<https://cospaces.io/edu/>).

After the virtual workshop, preservice teachers became more familiar with the platform and viewed examples (e.g., Goldilocks and the Three Bears). After exploring the tool, PSTs began coding to design their book, previewing the story periodically, and troubleshooting any technical issues. The CoSpaces Edu software was utilized to create each scene for their book (see Fig. 1).

Pre-Service Teachers coded using the drag and drop feature embedded in the CoSpaces Edu app to include multiple modes of communication into their book design (see Fig. 2). The free version limits a teacher to one class of 29 students, ability to create two CoSpaces, upload 10 external files, and use the basic features of CoBlocks coding software whereas the PRO account allows users to create 3D objects and utilize all features. Some aspects of the digital book interface could not be used without a PRO (i.e., professional) account, but due to the COVID-19 pandemic, the developer provided free access to a PRO account.

Using the CoSpaces Edu software, PSTs produced digital children's books viewable in any web browser, with the capability to view in virtual reality. When finished, books were published and shared to the class YouTube channel.

Data Collection and Analysis

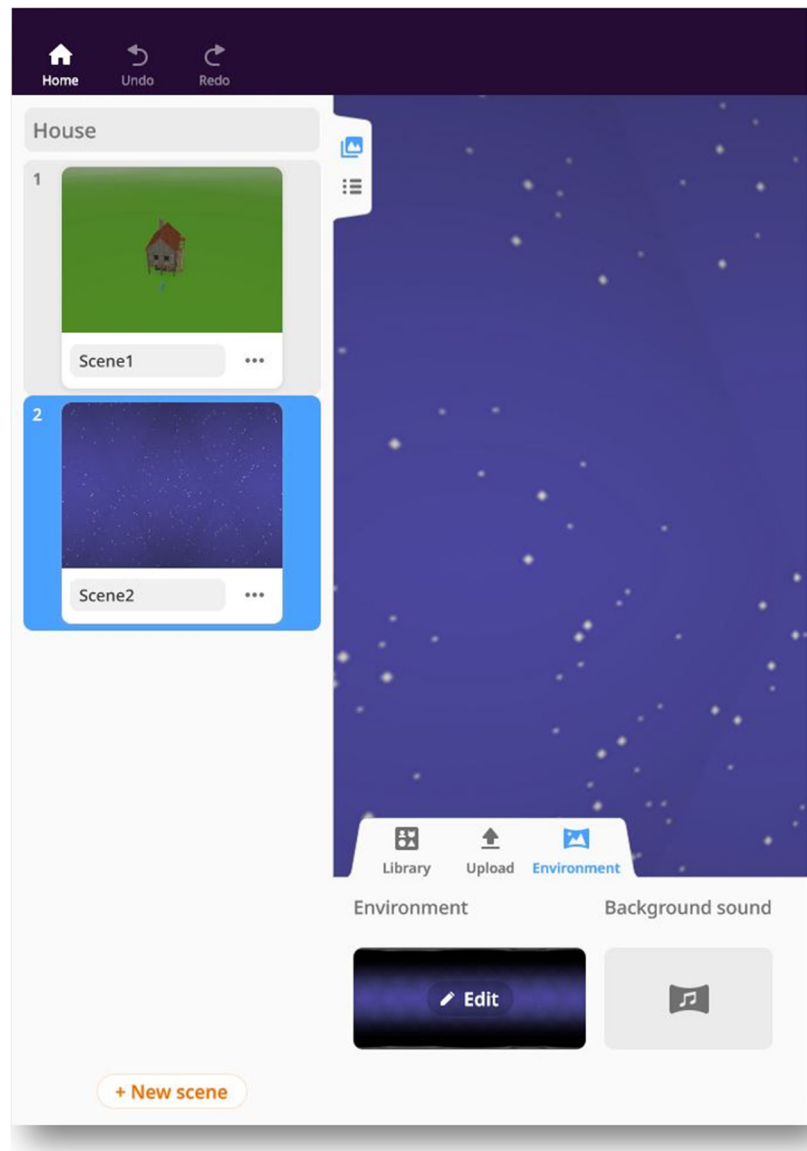
Data collection included digital book artifacts and participant reflections. Three students did not complete the reflection assignments, so the researcher analyzed twenty-five written reflections.

Content Analysis A six-step process was followed to perform a content analysis: 1) reliance on the scientific method, 2) message as the unit of analysis, 3) counting key categories, 4) summarizing, 5) applicability to all contexts, and 6) analysis of message characteristics. Because this approach adheres to the scientific method, this helped situate the study from an exploratory perspective. Table 1 details a visual of the content analysis process executed in this study.

The study's research questions considered possibilities for whether, and to what extent, the study participants would be capable of learning basic coding skills to design digital books. No assumption was made because assumptions about technological competence of PSTs' technology are often inaccurate (e.g., Lei, 2009).

Each digital book artifact served as the unit of analysis because each artifact represented the coded visual attributes. Categories that were used for analysis included modes of communication (e.g., character dialogue) that PSTs generated in their digital book (summarizing took place following the descriptive analysis). The modes of communication were analyzed within each book, as well as from a top down perspective to compare how modes of communication were included in each book artifact. Applicability to all contexts considered

Fig. 1 CoSpaces Edu environmental scenes design



how the data could be interpreted more broadly, such as the relevance of digital books to learning and instruction, and implications for digital designers when designing digital books. An analysis of the message characteristics illuminated possibilities and challenges associated with PSTs' ability to design digital books with visual elements, as well as encounters with technological difficulties.

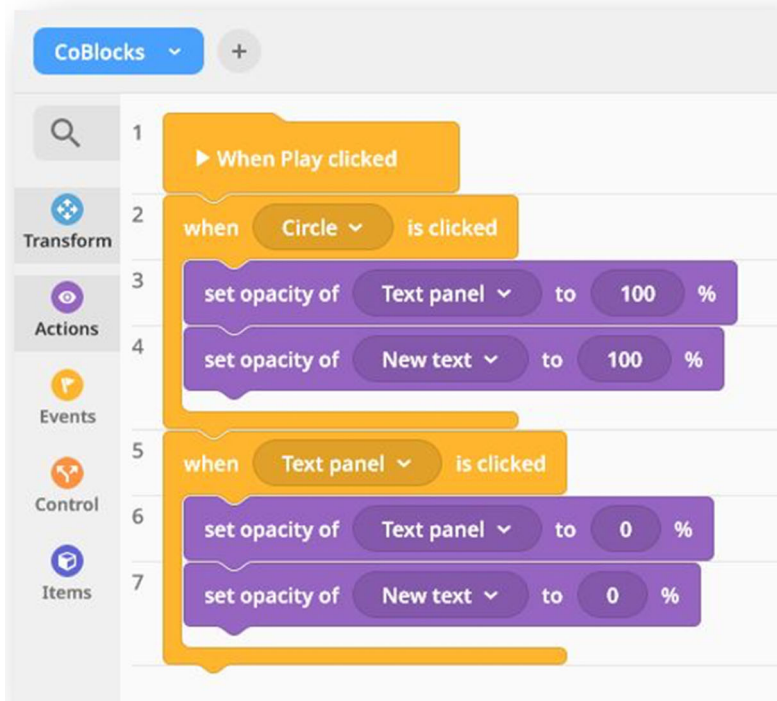
Thematic Analysis Pre-Service Teachers completed an open-ended reflection about their digital book design experience, to identify challenges, possibilities, and intentions. Analysis of reflections followed Braun and Clarke's (2006) six phases to inductive thematic analysis: 1) researcher becomes familiar with the data, 2) generates initial codes, 3) searches for themes, 4) reviews themes, 5) defines and names themes, and 6) produces a final report.

This specific approach to thematic analysis is unique because findings require a situated and interactive process reflecting the data, researcher positionality, and research context. Positionality is important to Braun and Clarke (2019, p. 15) because,

Researchers within a qualitative paradigm tend to treat research as a subjective process. Given that understanding, it is disingenuous to evoke a process whereby themes simply emerge, instead of being active co-productions on the part of the researcher, the data/participants and context.

In terms of positionality, the researcher had little prior coding experience, with one instance using robotics to bring movement to literature-based dioramas. The

Fig. 2 CoBlocks drag and drop puzzle coding



research context is unique because PSTs went from in-person instruction to a remote learning context, forcing the workshop and digital book design to be completed remotely.

Adhering to the six phases of inductive thematic analysis, Phase One involved reading through every reflection without making annotations. Phase Two entailed re-reading the reflective summaries to identify initial codes, (e.g., good/bad at using technology, time spent, happiness/frustration). Next, Phase Three led to counting and sorting by the ten coded categories and reading across and between coded categories to identify themes. With themes established, Phase Four included a review of proposed themes. Phase Five entailed revising themes further based on the proposed themes in the data. A report of the final themes, and Phase Six, is reported in the results to describe PSTs' reflection of designing a digital book with multiple modes of communication.

Results

Pre-Service Teachers coded ten digital books. Content analysis quantified the multiple modes of communication that were applied to each book design. Reflections reveal detailed experiences of the book design process and possibilities for designing and reading digital books in the classroom.

Modes of Communication in Digital Books

Content analysis of digital books revealed PSTs have emerging Visual Literacy skills, including the ability to read, write, think, and learn visually by creating visually engaging images (Kędra, 2018). Pre-Service Teachers created books with multiple elements within each scene, to include captions, character names, and audio narration (see Fig. 3).

Each book was visually unique because it contained a variety of multiple modes of communication. Graphics were colorful, with rich, vivid contrasts. The digital book allowed for VL enhancement with the addition of movement, where characters interacted with each other and moved around within each scene. Character images varied by gender, race, and age. Some PSTs chose to include more detail in their book than others which contributed to the modes of communication, such as, the addition of more scenes, multiple characters, dialogue, and highly detailed landscape. For books that included audio narration, the PST read the text aloud to the reader.

The digital book creation experience supported literacy skills such as comprehension, fluency, and poetic skills. The book was viewable in a video format or the reader could self-pace by clicking the arrows at the bottom of each scene to navigate from one screen to the next. In terms of sharing, the book link could be uploaded to any website for viewing, including social media sites. Pre-Service Teachers' shared their books on the class YouTube channel with the intention of

Table 1 Content analysis process executed in this study (royalty-free images obtained from <https://pixabay.com>)




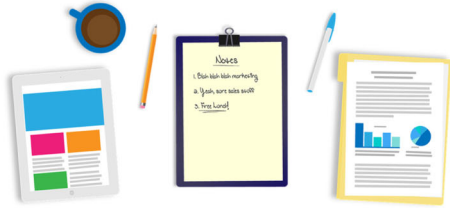

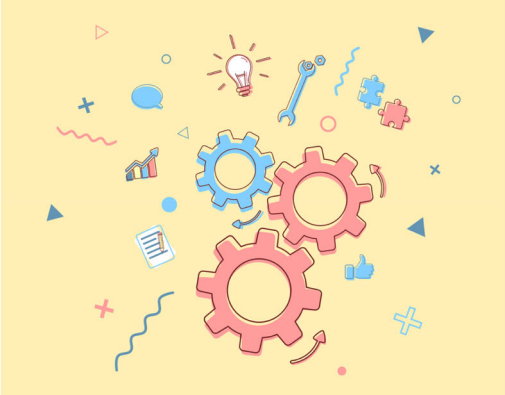
Step	Definition	Image	Action Taken
1	Scientific Method		Exploring possibilities
2	Message as the unit of analysis		Book artifacts (in CoSpaces Edu and uploaded to YouTube)
3	Counting key categories		Counting modes of communication (e.g., characters, number of scenes, dialogue, narration, captions, interaction, other movement)
4	Summarizing		Collectively observe the average length and features of the books.
5	Applicability to all contexts		Relevance to learning, instruction, and digital design.
6	Analysis of message characteristics		PSTs' ability to design digital books with visual elements, and combat technological difficulties.



Fig. 3 Scene 8 from the adapted *White Lilacs*, identifying Rose Lee and Grandfather

having elementary students read their books, either independently or through a shared reading experience.

Pre-Service Teachers created books which were adapted versions of children's books (e.g., *Bud, Not Buddy*; *Love that Dog*; *The Boy on the Wooden Box*; *Extra Credit*). An animated and virtual reality capable version of the book, *Bud, Not Buddy*, by Christopher Paul Curtis is seen in Fig. 4. The

original book is a chapter book for 4th/5th graders, but this animated children's version was designed for K-1.

The inclusion of multiple modes of communication techniques varied. Two of the ten books were pre-recorded, with a reading time of 2:57 and 6:09 min. The remaining eight books took an average of six minutes to read. Number of book scenes ranged from 3 to 18, with an average of 11 scenes per book. Nine



Fig. 4 Scene 1 from the adapted *Bud, Not Buddy*, with character movement and captions

(90.00%) of the books contained captions, three (30.00%) were narrated with audio, and seven (70.00%) had character interactions (i.e., dialogue). One book included a photo of a local city park from the PST's community.

For the seven books with dialogue, characters conversed with one another on screen, an engaging feature for the reader. The books were viewable in virtual reality, such as in the adapted version of *Love that Dog* (see Fig. 5).

Reflections

Thematic analysis of twenty-five reflections identified two themes. Pre-Service Teachers reflected most about the possibilities and visual affordances of digital book reading in the classroom. Second, PSTs emphasized their technological challenges and time required to learn to use a new tool.

Possibilities and Visual Affordances of Digital Book Reading in the Classroom Under this most prominent theme, PSTs described digital books as a creative outlet to enable students to focus on the process of constructing self-designed digital books ($n = 24$, 96%). Just over half acknowledged visual affordances when reading digital books ($n = 15$, 60%).

After PSTs created their digital books, they recognized possibilities for including the digital book design process in their future classrooms. For instance, *I think if I introduced this into the classroom I would definitely emphasize with my students the idea of the process being more important than the product so my students don't get frustrated.* Another group relayed a similar strategy to allow students to explore the tool. For example, *We would set aside time for a day or two to experiment with the site and allow the class to ask questions and understand the site itself before asking them to create a virtual story.*

To consider the possibility of students designing digital books, a Pre-Service Teacher stated, *I think assignments like this could also be used as something to work on once students finish their other assigned work because as for me I would*

label it as more of a 'fun' or creative project. New ways for engaging their future students with text when designing a digital book could be that,

The digital book is a great way for students to individually or collaboratively work on assignments that require text and images. I think that this would be really fun for students who are creative and want to use literature in a different way.

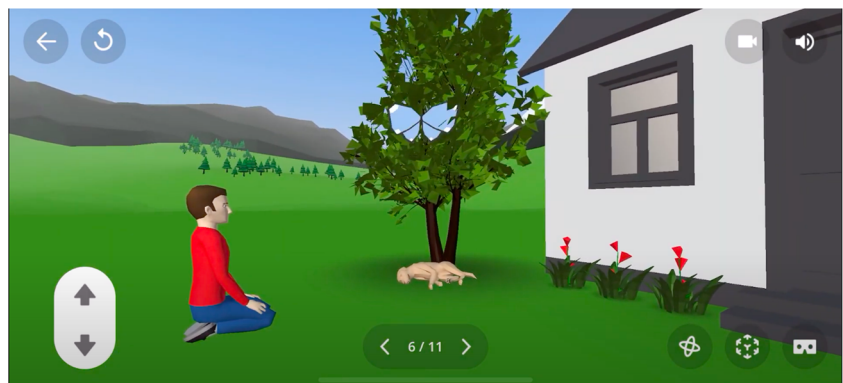
When planning for students to create books, precautions were mentioned to carefully scaffold the digital book design process. Therefore, to help students be successful in creating their digital books, one recommendation noted, *I would have a story template set up already, and have the class build the story with me, creating dialogue for the characters rather than having students create their own stories from scratch.* Others envisioned the book design as a capstone project, such that,

This is something we feel would be very beneficial to our students because they could be very creative. Their work would be very different and would show their individual understanding of the subject matter. This would be a great end of the year project since it would take a while to finish, but it would show the students complete understanding of a novel or subject matter.

In terms of age appropriateness, PSTs could envision students in 4th, 5th, and 6th grade classrooms coding to design a digital book. One assumption about students designing digital books was that, *I think it is fun for students who are older and into computers, gaming and coding, designing and a lot more.*

With the abundance of possibilities surrounding the design of digital books, the potential for visual affordances within digital books were recognized. As explained by one PST's reflection on the possible modes of communication and opportunity to engage in creativity,

Fig. 5 Scene 6 from the adapted *Love that Dog*, with no captions, viewable in virtual reality



I was more interested in what features I could use and how I can make my project the way I wanted it. It was very exciting to use this type of technology because I was not limited to what I wanted to create.

Specifically, features allow the user to *Maneuver the characters and the environment the way that would best fit the story line, and create dialogue*, but it is essential to *Get [the] angles right and make the book and the characters look legit (sic) as possible*. There also appeared to be some enthusiasm associated with the visual design process. One PST commented that, *Seeing the faces for the characters start to come together, and each scenario we chose from the book begins to piece together to make an actual story that makes us excited*.

Several PSTs shared that reading a digital book is a different experience from reading a print one. Another mentioned, *The digital book places you in the scene with the character. It makes you feel as if you are apart (sic) of the story as well*.

Technological Challenges and Time Required to Learn to Use a New Tool Though imagined possibilities took precedence as the dominant theme, this required PSTs to endure technological difficulties. Tied to the context of this study, PSTs did not find the asynchronous workshop created by the university library helpful ($n = 20$, 80%). Primarily, they struggled to learn to use the tool ($n = 19$, 76%) because of the time investment required ($n = 14$, 56%). In reflecting on their digital book design process, PSTs self-acknowledged whether they were tech-savvy ($n = 9$, 36%).

As a result of the COVID-19 pandemic, what was initially scheduled as an in-person workshop with the university library became an asynchronous training video. One of the PST comments addressed this,

I think in the beginning it was a lot harder than I anticipated. This is a project that would have been helpful to have done in class so I could ask any necessary questions. But unfortunately, we didn't get to do that due to the interruption of the Coronavirus. It was challenging because it was so new and we had never completed a project like this.

Other PSTs contended they could have enjoyed learning to design a digital book more if conditions were different. A PST reflected, *If we got the chance to still be in an in-person class, I feel like we all would have been able to answer questions, and to help us figure out what works best*. The overall perception of the workshop was that, *Maybe if an actual person taught me in depth on how to use it, I would like it more*.

Developer tutorials posted on the CoSpaces Edu website and YouTube were helpful for some. One PST shared, *The website, I preferred to do it there instead of the app, was very*

intimidating at first. Trying to figure out how to add backgrounds, where to position objects, [and] how to size them was difficult. Other challenges included *Things like code scripting, limited unlocked materials, background knowledge, etc*. Limitations of the tool were that the free version is *Very limited and didn't offer much for us to work with to create a virtual story that we pictured, and The software program only allows for one group member to work on it at a time*.

The greatest frustration with learning to use the tool appeared to stem from the time required to learn to navigate the commands. In general, most PSTs reflected in this manner, emphasizing, *this project was definitely more difficult than I was anticipating, and took many hours*. To detail what took extensive time, one relayed that *a vast majority of my time was spent trying to figure out the placements of animals or characters I had in my story*. Another suggested, *I wish it was more like the game The Sims, where you just plot people in and everything is already made up (i.e. the houses, characters)*.

Without prompting, nine PSTs referenced the extent to which they were tech-savvy: six felt their skills were subpar, two felt equipped, and one was neutral. One felt designing a digital book was a worthwhile task and shared that *it was a fun way to test my technology skills*, and that they *also learned a lot a long (sic) the way*. For the others who self-identified as being technologically literate, their reflection mentioned, *when I ran into a problem I would try to find a tutorial online that could help me*. This is in contrast to a PST who lacked confidence in using technology, who admitted, *I am not technically savvy in any way, and the whole app, no matter how many tutorials I watched, was difficult to navigate*.

The PST who held a neutral stance toward being technology-savvy shared how their perceptions influenced their initial understanding of the project,

At the beginning, when we were told we are going to learn how to code a digital book, I immediately began to stress because 'coding', to me, is such a small word that packs a big punch. If that makes sense. I imagined the difficulty level would be high.

Among the other PSTs who believed they did not possess the appropriate level of technology knowledge to design a digital book, they associated a lack of confidence to their limited creativity and whether they were confident computer users. A PST who felt ill-equipped to use technology shared, *It took me out of my comfort zone because dealing with computers is definitely not a strong point for me*.

Limitations

This study includes PSTs from one context, one classroom, and one technology application, to design one digital book.

Relevant to case study research, findings in this study cannot be generalized to other populations and contexts. To temper interpretation bias, findings were analyzed using systematic approaches to content analysis and thematic analysis.

Discussion and Implications

Pre-Service Teachers need to be explicitly taught visual modes of communication in teacher preparation programs (Sosa, 2009; Yeh & Lohr, 2010). This discussion attends to PSTs' ability to integrate multiple modes of communication into the design of their digital books. Reflections on designing digital books sheds light on the possibilities for students and teachers to create and read digital books. This creates an opportunity for authentic meaning-making. Technological encounters and time required to learn to use a new tool confirm the limited inclusion of multiple modes of communication within the digital book artifacts.

Multiple Modes of Communication in Digital Books

Digital books have evolved considerably since reading a book on a computer with a CD-ROM (Shamir & Korat, 2006). Young children desire to read with print and digital texts, and read both print and digital texts in the home and school (Eutsler et al., 2020). However, understanding what it means to be literate considers an acknowledgement of visual meaning making systems (NCTE, 2005) and requires engaging students with texts with an explicit focus on the visual elements (Prior et al., 2012). This study sought to address the development of Pre-Service Teachers' knowledge and ability to explicitly integrate modes of communication into the design of digital books.

In this study, PSTs' applied visual elements within their books based on their knowledge of VL and, because of varying levels of VL knowledge, books were vastly different from one another. The presence of visual elements (e.g., scene images, character captions) in digital books appeared more out of convenience, to include what was most readily available in the digital tool. Because of technological difficulties, it is unclear to what extent PSTs chose not to include multiple modes of communication (e.g., captions, movement), or if the complexity of the tool itself may have inhibited their design. To note, only one book included an image from a PST's own community. Only one book contained all the modes of communication, or VL elements. This is concerning because PSTs in this study were designing a book primarily for a K-1 audience. By the junior year of their teacher preparation program, PSTs should be keenly aware of the importance of including visual detail in children's books.

Contributions to Multimodal Literacy Theory Each book feature (e.g., scene images, character movement) acted as a signpost, intended to engage the reader to understand the context, mood, and storyline (Kress, 2010). A lack of visual elements can hinder students' comprehension of text (e.g., Silverman & Piedmont, 2016). Therefore, when creating a digital book, visual elements should be at the forefront of the design. Supported by multimodal literacy theory (Jewitt & Kress, 2003; Kress, 2010), coding features enabled characters to dialogue with one another and use hand gestures, important elements of VL. Captions alternated between characters, making character interactions appear more realistic. Pre-Service Teachers also chose details to illustrate each scene. These characteristics indicate the importance of emphasizing the visual mode of communication in teacher preparation (Little, 2015; Sosa, 2009), to engage students in the reading process. Findings support the idea that a focus on visual aspects of a digital book (Lundy & Stephens, 2015) may help students practice reading skills and strategies.

Technological Difficulties The advantages of using block-based coding to design a digital book to help PSTs' become technologically literate seemed to outweigh the challenges associated with learning to use the tool. More emphasis was spent considering how digital books could, and should, support students' literacy development in the classroom. Additionally, after designing their book, PSTs in this study planned on using technology to support literacy instruction, in contrast to earlier research where teachers did not intend on using technology despite it improving students' literacy achievement (D'Agostino et al., 2016).

Among PSTs who were less satisfied, their dissatisfaction was associated with their time spent and challenge posed by learning a new technical skill. For some, the exploratory nature of designing a digital book could have contributed to their level of frustration. Pre-Service Teachers require time to learn a new skill, low-stakes exploration of technology, and mentoring and model teaching support (Fedon, 2017; Groth et al., 2007; Tondeur et al., 2012). Though highly structured technology support appeared to benefit some PSTs in this study, a noted benefit by Hutchison and Colwell (2016), the interruption of COVID-19 presented additional challenges, limiting PSTs to remote technical support.

Possibilities for Digital Books Pre-Service Teachers described an array of future teaching opportunities rich in teacher-directed and student-directed learning strategies that could be adapted in response to the age and skill-level of students. An apparent desire was expressed for students to code and design visually-enhanced books, to align with teachers' increasing use of digital books to support literacy achievement in the classroom (Eutsler et al., 2020). Ideas were expanded to focus on the need to foster students' digital literacy skills, and

PSTs were willing to learn new skills to be able to support their students reading digitally. These ideas and intention to use technology demonstrate the value of exposing PSTs to new technology tools within their teacher preparation program (Christ et al., 2019; Eutsler, 2021) and addresses the need for continued professional support (Tondeur et al., 2012). By including concepts like coding within teacher preparation programs (Ching et al., 2018), PSTs can better prepare their students to become literate for twenty-first-century workplaces (Walsh & Farren, 2018; Watts-Taffe et al., 2003).

This research also demonstrates how the integration of digital books can help draw attention to visual design elements in children's books. The need to explicitly teach VL concepts within teacher preparation programs was evidenced by the inconsistency of PSTs' ability to incorporate multiple modes of communication into the design of their digital books. Multimodal literacy theory emphasizes, that to some extent, visual supports are helpful for students to understand and engage with text (Jewitt & Kress, 2003; Kress, 2010). Pre-Service Teachers need to be explicitly shown how to identify VL elements (Little, 2015), but also engage in the design of books that contain VL elements, to better support students' digital literacy skills.

Additional implications apply to digital tool selection. In this study, technological difficulties were associated with learning to use the digital tool. Ease of use was associated with the affordances offered between the free and paid versions of CoSpaces Edu. These technical and access issues related to design seem to mimic the development of digital books. This alludes to the idea that teachers may be less likely to integrate digital books into their curriculum if they lack free and high-quality access to digital books. Some educational researchers have designed their own digital books for research (Wang & Huang, 2015), but these, among others, are unfortunately unavailable to other educators to share or read with their students. Other book developers should consider ways to provide open access to digital books, similar to Storyline Online (IMDb, 2002).

Future Research

With the design of digital books still in the early stages, there are several opportunities for research, both in teacher preparation and in upper elementary and middle-school classrooms. For example, future research might explore how to include Visual Literacy more expansively within teacher preparation programs. This could expose PSTs to multimodal literacy theory and VL pedagogies before designing and selecting books. This might reveal differences in terms of PSTs' knowledge of VL, technical skills, and modes of communication afforded by digital books. Before introducing a new technology, it might benefit PSTs to focus on visual elements of print books, which could better prepare them to apply VL attributes to create a shorter digital

book containing only a few scenes. Related research might also explore other tools to create digital books, with or without the integration of coding. Considerations for other digital book applications might include Adobe Spark, iMovie, Lego Movie Maker, PowerPoint, and Google slides, among others.

Other research could also explore conditions of reading digitally to investigate differences in students' comprehension when reading books that vary based on their prominent visual elements (e.g., image present vs. narration present). Related research could also investigate student attitudes, engagement, motivation, and desire to create and read digital books, with or without reading the book in virtual reality.

Conclusion

Guided by Visual Literacy concepts (Kędra, 2018) and multimodal literacy theory (Jewitt & Kress, 2003; Kress, 2010), the purpose of this study was for Pre-Service Teachers to learn basic block-based coding to design digital books containing multiple modes of communication. This study is an early contribution to VL Theory with a focus on visual reading, visual writing, visual thinking, visual learning, and applied image use (Kędra, 2018). Results indicate PSTs' applied emergent levels of VL knowledge, evidenced by a range of modes of communication, which were influenced by PSTs' imagined possibilities for designing digital books.

Technological challenges with the tool itself and beliefs about technological competence impeded PSTs' process of learning to use new technology. As new technologies are introduced, more attention to the visual mode of communication and multimodal learning theory creates a ripe opportunity for teacher educators to transform literacy teacher preparation, specifically how teachers can be more supportive of students reading in this digital era. New technology tools offer enhancing opportunities to provide authentic and visually engaging teaching and learning experiences. Applied practices should emphasize teachers and students creating digital books and fostering reading experiences which include multiple modes of communication, with a focus on visual elements.

Declarations

Conflict of Interest The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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