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Patterns of Digital Text and Tool Integration in Preservice Teachers' Literacy Instruction

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Worldwide, it is recommended that teachers integrate digital texts and tools in their literacy instruction (Chaudron, Di Gioia, & Gemo, 2018; International Literacy Association, 2009). For example, a study of how young children learn to use technology across 17 countries concluded that they develop better skills when "their school integrates digital technology meaningfully" to "develop digital literacy" (p. 2.) Further, the International Literacy Association, with members from across 146 countries, argues that, "Literacy educators have a responsibility to integrate these new literacies into the curriculum to prepare students for successful civic participation in a global environment" (2009, n.p.).

Despite the importance of integrating digital texts and tools into literacy instruction to meet these goals and standards, existing research is limited in a few important ways. First, while existing research shows that teachers often have difficulties aligning their digital text or tool selections effectively with their lesson objectives (Fernholz, 2014; Hutchison & Colwell, 2016; Kaalberg, 2014), it has not explored what *aspects* of selection are most difficult for teachers. Knowing this would inform what aspects of selection might need to be focused on more in teacher preparation or development. Second, while a couple of studies have shown that about half of inservice teachers integrate digital texts or tools proficiently (Hutchison & Woodward, 2018; Paratore, O'Brien, Jimenez, Salinas, & Ly, 2016; Woodward & Hutchison, 2018), there is lack of data about their *specific proficiencies* for integrating digital texts or tools in literacy instruction. Knowing this would inform what proficiencies for integration might need to be further developed. Third, while research has explored the connections between integrating technology in literacy instruction and students' outcomes (e.g., Hutchison & Woodward, 2018; Kao, Tsia, Lui, & Yang, 2016; Price-Dennis, Holmes, & Smith, 2015; Vasinda, Kande, & Redmond-Sanogo, 2015), it has not explored how the specific characteristics of *digital text or*

tool selection and *instructional integration* are related to student outcomes. Knowing this would inform what characteristics might be beneficial to focus on in teacher preparation and development.

To address these issues, our study aimed to answer the following research questions:

1. How are the characteristics of preservice teachers' (PTs') (a) digital text or tool selection and (b) integrations of these in literacy instruction, related with students' outcomes for *transcendent literacy skill or strategy objectives* (i.e., those skills or strategies that transcend paper or digital contexts—e.g., inferring, connecting, etc.) across different kinds of literacy objectives (e.g., comprehension, word study, etc.)?
2. How are the characteristics of PTs' (a) digital text or tool selection and (b) integrations of these in literacy instruction, related with students' outcomes for *digital feature use* (i.e., ability to use digital features to support meeting the transcendent literacy skill or strategy objective—e.g., activating a hotspot to support determining a vocabulary word meaning) across different kinds of literacy objectives (e.g., comprehension, word study, etc.)?

DigiLit Framework

Our research is informed by the DigiLit Framework. This framework is research-based and designed to evaluate teachers' selections *and* integrations of digital texts or tools *specifically for literacy instruction* (Baxa & Christ, 2018). There are other broader frameworks for evaluating teachers' integration of technology in instruction across disciplines (e.g., Mishra & Koehler, 2006). Also, there are narrower frameworks that focus solely on app, e-book, *or* website evaluation (Dragulanescu, 2002; Israelson, 2015; Morgan, 2013) or determining how transformative instruction is (Puentedura, 2010). However, we chose to use the DigiLit Framework to guide our study because it aligns best with our research questions as compared to

other frameworks.

DigiLit: Criteria for Digital Text or Tool Selection

The DigiLit framework has four research-based criteria for digital text or tool selection for literacy instruction. The first is to evaluate the digital text or tool for *literacy content accuracy*. This would include evaluating accuracy of spelling, grammar, and application of word patterns (Dragulanescu, 2002; Israelson, 2015; Morgan 2013).

The second criterion is to assess the *quality* of the digital text or tool for supporting literacy development. This would include evaluating the developmental appropriateness, whether or not features are distracting, whether digital features support the learning the objective, and whether digital books have continuous text vs. 1-2 sentence excerpts of text (Dragulanescu, 2002; Israelson, 2015; Morgan, 2013; Taylor, Pearson, Peterson, & Rodriguez, 2003).

The third criterion is to assess the *intuitiveness* of the digital text or tool features. If a student is likely to figure out how to use the app features independently, then they would be considered intuitive (Israelson, 2015; Morgan 2013).

The fourth criterion is to assess *interactivity*. If an app provides the student opportunities to interact with digital features to promote active learning, then it would be considered interactive (Dragulanescu, 2002; Israelson, 2015; Morgan, 2013). The gradations of success with which teachers might apply each of these criteria are presented in the rubric in Figure 1.

DigiLit: Criteria for Integrating Digital Texts or Tools in Instruction

The DigiLit Framework provides five research-based criteria for integrating digital texts or tools in literacy instruction (Duke & Pearson, 2009; Mishra & Koehler, 2006; Pearson & Gallagher, 1983; Rupley, Blair, & Nichols, 2009). First, teachers should *model a transcendent literacy skill or strategy* (recall that these are those skills or strategies that transcend paper or

digital contexts). An example of this is modeling how to use text clues and prior knowledge to make an inference with text.

Second, teachers should *guide a student's use of a transcendent literacy skill or strategy*. Aligned with the previous example, a teacher would elicit the child's text clue use, identification of prior knowledge, and use of reasoning to generate an inference with text.

Third, teachers should *model digital feature use* (i.e., ability to use digital features to support meeting the transcendent literacy skill or strategy objective). For example, in an app book (i.e., a kind of digital book offered on tablets that often has interactive features, such as hotspots), the teacher might show the child how to use a hotspot to gain extra clues that might help in making an inference.

Fourth, teachers should *guide a student's use of digital features* to support attaining the transcendent literacy objective. For example, the teacher might prompt and support the child to try to find and use a hotspot that provides additional clues to support an inference.

Fifth, the instruction should capitalize on the features of digital texts or tools to *transform the tasks* in the lesson (Puentedura, 2010). This includes modifying or redefining the literacy task, rather than replicating what could also be done with paper and pencil tools. In the examples above, using hotspots to garner *additional modes of information* that provide clues to support making an inference is transformational. It modifies the literacy task by including animation and sound activated by the hotspots, which provide new clue sources. The gradations of success with which teachers achieve these criteria are presented in the rubric in Figure 2.

Literature Review

To inform our study, we reviewed research related to (a) teachers' digital text or tool selections, (b) teachers' integration of digital texts or tools in literacy instruction, and (c)

students' outcomes related to these. We included any study in which PTs or inservice teachers made the decisions about the selection and integration of digital texts or tools for literacy instruction by themselves. (Note: we did not review studies outside this scope that focused on teachers' perceptions, attitudes, or beliefs about integrating digital texts or tools that did not include data about *actual instances* of selection or integration; or studies in which researchers chose the digital texts or tools or designed or guided their integration *for* teachers.)

Teachers' Digital Text or Tool Selections in Literacy Instruction

While there are several articles written to guide teachers' selections of digital texts or tools (Baxa & Christ, 2018; Cahill & McGill-Franzen, 2013; Dragulanescu, 2002; Isrealson, 2015; Morgan), far fewer publications have explored *teachers' actual selections* in their everyday practice. While one case study showed that an inservice teacher chose multiple apps that allowed for high interactivity and supported literacy development (e.g., *Flipboard* to curate stories and *Bitstrips* to generate student-made comics), this example was the minority (Price-Dennis et al., 2015). For example, another case study showed that an inservice teacher selected apps that allowed children to practice spelling or phonic patterns (i.e., *Rocket Speller* and *Endless ABC*) because she thought they were "cute" and "colorful", despite that they had distracting features that did not support students' learning (Israelson, 2014, pp. 5-6). Further, studies have shown that both PTs and inservice teachers have difficulty selecting digital texts or tools that align with their instructional objectives (Fernholz, 2014; Hutchison & Colwell, 2016; Kaalberg, 2014).

These studies paint a broad picture about teachers' successes and difficulties selecting digital texts and tools. However, they lack more specific analysis concerning whether teachers' selections align with a set of research-based criteria for selection, such as in the DigiLit Framework. This limits our understanding about what aspects of selection are most difficult for

teachers. Knowing this information would inform recommendations for teacher preparation or development to improve teachers' digital text or tool selections. Such recommendations could enhance and accelerate research findings that professional development improves teachers' digital text or tool selections over time (Fernholz, 2014; Hutchison & Colwell, 2016; Kaalberg, 2014).

Teachers' Integration of Digital Texts or Tools in Literacy Instruction

Most existing studies described, rather than evaluated, PTs and inservice teachers' integrations of digital texts and tools in literacy instruction. These studies described the myriad ways that teachers used digital texts and tools in literacy instruction. For example, a few studies showed that inservice teachers were using digital texts and tools primarily for skill drill (Israelson, 2014; Lu, Ottenbreit-Leftwich, Ding, & Glazewski, 2017; McDermott & Gormley, 2015). In contrast, others studies showed that both PTs and inservice teachers were using digital tools for communication and collaboration, such as creating documents, documenting their thinking, sharing multimedia content, and creating interactive learning communities (Hutchison & Beschorner, 2015; Jahnke & Kumar, 2014; Saudelli & Ciampa, 2016). Likewise, studies showed that inservice teachers used digital tools to solve problems (Jahnke & Kumar, 2014), engage in multimodal composing and revision (Hutchison & Beschorner, 2015; Lu et al., 2017), individualize students' learning experiences (Saudelli & Ciampa, 2016), generate students' interest and attention (Hutchison & Beschorner, 2015), and help students understand autism (Price-Dennis et al., 2015).

A much smaller body of research evaluated the effectiveness of PTs and inservice teachers' digital text and tool integrations in literacy instruction. One study showed that 66% of PTs' digital text or tool integration was "meaningful" and most instruction included "literacy

teaching actions (e.g., demonstrating, explaining)" (Paratore et al., 2016, p. 256-257). However, another study found that PTs needed appropriate preparation before they could effectively integrate digital texts and tools in instruction (Vasinda et al., 2015). Likewise, inservice teachers' integrations of digital texts or tools in literacy instruction, after professional development, were rated as *advanced* in 50% of classroom observations, *proficient* in 35% of classroom observations, and *not proficient* in 15% of classroom observations (Hutchison & Woodward, 2018). However, another study of three inservice teachers showed that, even with professional development, only one teacher had "high" integration, which was indicated by specific plans for using iPads in her lessons, while the other two had "low" integration, which was indicated by "no evidence that the iPad was used" in the lessons (Woodward & Hutchison, 2018, p. 628). While these studies indicate PTs' and inservice teachers' *overall proficiency* for integrating digital texts or tools in literacy instruction, they do not explore the *specific aspects of teachers' proficiencies*, or lack thereof. For example, no previous study has evaluated the effectiveness of PTs' or inservice teachers' integration across multiple research-based criteria, such as whether or not they (a) model and guide students to practice transcendent literacy skills, (b) model and guide them to practice digital feature use, or (c) capitalize on the features of digital texts or tools to transform the tasks in the lesson. Understanding teachers' proficiencies for each of these characteristics of instructional integration will inform whether specific areas of instructional integration might benefit from more or different teacher preparation or development.

Students' Outcomes Related to Digital Text or Tool Use

Previous studies found that teachers' digital text or tool integration enhanced students' engagement and motivation (Ciampa, 2012; Israelson, 2014; Kao et al., 2016; Vasinda et al., 2015). It also helped peers connect and understand one another better (Price-Dennis et al., 2015),

increased students' comprehension (Kao et al., 2016). Further, it improved students' digital literacies competencies (Hutchison & Woodward, 2018).

Additionally, several studies explored students' outcomes related to their use of specific digital features. For example, research showed that emergent readers' comprehension was supported by listening to a digital book using the *Read to Me Mode* (Christ, Wang, Chiu, & Cho, 2019; Trushell, Maitland, & Burrell, 2003). This mode read the story aloud as the child turned the pages. Likewise, students' vocabulary and comprehension outcomes were supported by hotspots that provided more information related to the story's or word's meanings (Christ, Wang, Chiu, & Cho, 2019; Christ, Wang, Hughes, Strekalova-Hughes, 2019; Korat & Blau, 2010; Neuman & Kaefer, 2013; Smeets & Bus, 2012; Verhallen & Bus, 2010; Wang, Christ, Chiu, & Strekalova-Hughes, 2019). For example, when a student pressed a hotspot to activate animation and sound that provided word-meaning clues, this facilitated better vocabulary learning (Christ, Wang, Chiu, & Cho, 2019; Christ, Wang, Chiu, Strekalova-Hughes, 2019; Wang, Christ, Chiu, & Strekalova-Hughes, 2019). Further, students' word recognition was supported by digital books in which the student could tap on a word and the book would read it aloud (Larson, 2010). Finally, research showed that multiple digital features facilitated students' multimodal composition: drawing, typing, photo uploading, and audio/video recording options (Ching & Wang, 2012; Rowe & Miller, 2016). This body of research suggests that characteristics of teachers' digital text and tool selections and student outcomes are likely related. However, these relations have not yet been empirically tested.

Also, classroom teachers' professional development, using the Technology Integration Planning Cycle Model, was related to positive student outcomes for digital competencies as measured by better performance on the *Survey of Internet Use and Online Reading* (Hutchison &

Woodward, 2018). The Planning Cycle included teachers identifying the (a) instructional goal, (b) instructional approach, (c) tool selection, (d) tool's contribution to instruction, and (e) constraints of the tool; and then providing instruction using the tool. Professional development to support teachers' engagement in this cycle included providing (a) resources and lesson examples, (b) participation in a professional learning community, (c) access to an instructional coach, and (d) reflection and reflective feedback. This research underscores the importance of providing teacher preparation or development to improve students' outcomes.

While existing studies have explored students' outcomes related to the use of digital texts or tools in literacy instruction (i.e., use→ outcomes), they have not explored how specific characteristics of teachers' digital text or tool selections (i.e., *content accuracy*, *quality*, *intuitiveness*, *interactivity*) or integrations (i.e., *modeling and guiding general digital text or tool use*, *modeling and guiding digital feature use*, and *capitalizing on the features of digital texts or tools to transform the task in the lesson*) are related to students' outcomes. Understanding these relations could inform teacher preparation or development to maximize students' positive outcomes.

Methods

Participants

The first author invited all PTs who were enrolled in an undergraduate elementary education literacy teaching methods course at a Midwestern university to participate in this study. Then, according to the approved Institutional Review Board plan, their consent forms were collected. These forms were not reviewed until after students' final grades were submitted. This

was to avoid any perceived favor or coercion. Thirty-nine PTs chose to participate. There were no discernable differences in age, race, or grades for the course between those students who participated and those who did not. Of those PTs who participated, two were male and 37 were female. Two participants were African-American, one was a European immigrant, and 36 were Caucasian and born in the U.S. One teacher was in her forties, and 38 were in their twenties. All PTs had taken two previous courses in literacy teaching methods, one previous educational technologies course, and were in their final year of coursework before student teaching.

Setting and Course Description

The courses in which data were collected for this study focused on assessment-based literacy instruction and were taught by the first author to ensure continuity of instruction and the focal assignment. These were service-learning courses. PTs met their professor for classes at a local community center and spent one hour of each class teaching the children in the afterschool program. The center served children from the surrounding underserved community neighborhoods. Children were African-American or Mexican-American and in elementary grades.

One of the assignment requirements was that all PTs integrate digital texts or tools and provide digital literacies instruction with children across the semester. The stated goal was to transform children's learning experiences by using digital texts or tools to support the literacy objectives being taught. Thus, student outcomes in this study were the outcomes for each lesson objective taught by the PTs. Coursework included each PT choosing and submitting one to three videos of their instruction to be evaluated. Each submitted video showed one PTs integration of digital texts or tools in one literacy lesson with their student. Videos were chosen from 10

literacy lessons that occurred one-to-one across the semester. This meant that typically PTs submitted their best examples from about 10 lessons that they had taught during the semester.

To prepare for this assignment, PTs engaged in readings about literacy teaching methods and technology integration. They also engaged in two kinds of video-based discussions with their professor and peers in class: (1) discussions about video case studies that showed digital text or tool selection and integration in literacy lessons; and (2) reflective discussions about videos of their own instruction in which they were trying to integrate digital texts or tools across the semester. PTs engaged in a cycle similar to the Technology Integration Planning Cycle Model (Hutchison & Woodward, 2018). The first author provided instruction for PTs that included resources and examples of effective digital text and tool selections and integrations, coached them during their lessons, and engaged them in both individual reflections on their video-recorded lessons and group reflective discussions in which PTs shared video clips from their instruction, posed questions, and discussed and identified suggestions for improving their practice. Further, the PTs engaged in a similar planning cycle to the Technology Integration Planning Cycle Model. They first identified instructional objectives based on the literacy assessments they had administered to their students as part of the class. Then they chose digital texts or tools and methods for integration them using the criteria in the DigiLit Framework. Finally, they implemented instruction. It is important to note that the DigiLit Framework had not yet been developed at the time of data collection, and so it was not shared with PTs as part of their professional development. However, the first author did share all the principles for effective digital text and tool selection and integration that are in the DigiLit Framework.

PTs had access to tablets and laptops via the university's Educational Resource Lab. There were apps books and tools available on the tablets, such as Doodlecast, Notability, app

books, etc. PTs were also able to download apps from their own app store accounts onto the university devices. Many PTs also had their own tablets or laptops. Given that apps and websites were most easily accessible via these devices, most PTs used these resources.

Data Collection

The first author collected 88 video-recorded literacy lesson examples, as described above, from the 39 PTs (2 video examples per PT on average; range 1-3). Each lesson showed PTs' integration of digital texts or tools in literacy instruction and their student's outcomes during the lesson.

Data Scoring

Digital text or tool selection. The first two authors used the DigiLit Framework criteria to evaluate and score PTs' digital text or tool selection for each of the 88 lessons (Baxa & Christ, 2018; see Figure 1). Each of the digital text or tool selection criterion was evaluated across three gradations: *(0) low alignment with criteria, (1) moderate alignment with criteria,* or *(2) high alignment with criteria*. The gradations of PTs' success aligning with the criteria was scored for digital text or tool content accuracy, quality of digital features for supporting literacy development, intuitiveness, and user interactivity. It is important to note that *intuitiveness* referred to how easy it was to figure out how to identify a digital function for potential use (e.g., know that a hotspot existed), but it did not refer to how easy it was to figure out how to use it *strategically* to meet a specific literacy objective (e.g., using the hotspot to provide clues to make an inference).

Digital text or tool integration. The first two authors used the DigiLit criteria for digital text or tool integration to evaluate the teaching for all 88 lessons (Baxa & Christ, 2018; see Figure 2). Gradations of PTs' effectiveness in addressing each criterion were coded: *(0)*

ineffective teaching, (1) partially effective teaching, or *(2) effective teaching*. PTs' gradations of addressing the criteria were scored for modeling a transcendent literacy skill or strategy (recall that these are those skills or strategies that transcend paper or digital contexts—e.g., inferring, connecting, etc.), guiding students' use of a transcendent literacy skill or strategy, modeling the use of a digital feature to meet the transcendent literacy skill or strategy objective (e.g., activating a hotspot to support determining a vocabulary word meaning), guiding students' use of a digital feature to meet the transcendent literacy skill or strategy objective, and capitalizing on digital features to transform instruction.

Student outcomes. The first two authors evaluated two kinds of student outcomes from each of the 88 lesson videos. First, each student's ability to apply the transcendent literacy skill or strategy taught in the lesson was scored using the following gradations of outcomes: (0) *no use of the transcendent literacy skill or strategy*, (1) *use of the transcendent literacy skill or strategy with teacher support*, or (2) *independent use of the transcendent literacy skill or strategy*. (Note: Given that PTs' objectives were based on the students' needs identified in literacy assessments administered earlier in the methods course, there was evidence that most students were unable to engage in the focal transcendent literacy skill or strategy objective before the lesson.)

Second, for each of the 88 lessons, the student's ability to use the digital feature to meet the transcendent literacy skill or strategy objective was scored using the following gradations of outcomes: (0) *no use of the digital feature*, (1) *use of the digital feature with teacher support*, or (2) *independent use of the digital feature*. (Note: Students at the site did not have access to iPads at school or home, other than when PTs brought them for this instruction. Some students had a little experience using apps on their parents' phones, such as to access music and YouTube

videos. However, based on our conversations with students, they had not previously used the digital texts or tools that PTs were using in their lessons.)

Kinds of literacy objectives. The first two authors identified the kinds of literacy objectives that PTs addressed in each lesson. Categories included *emergent literacy, word study, comprehension, fluency,* and *multimodal composing*. Each lesson objective was identified as one of these to allow us to explore whether there were differences across instruction for different kinds of literacy objectives.

Scoring procedures. Scoring was done by the first two authors. Each scored PT selection, PT integration, student outcomes, and kind of literacy objective separately for each of the 88 lessons. Inter-coder agreement was high (between 74-96% across variables). Differences were discussed to establish consensus. Consensus codes were used for statistical analysis.

Statistical Analysis

Students' outcomes (i.e., *transcendent literacy skill or strategy use* and the *digital feature use*) were modeled with a *multivariate, multilevel logit regression* (Goldstein, 2011). Variables were entered according to time constraints, expected causal relationships (i.e., how one variable might affect another—e.g., the kind of literacy objective likely affected the digital text or tool selection, which in turn affected how it was integrated in the lesson), and likely importance.

$$\mathbf{Student\_Outcome}_{yij} = \beta_{y00} + \mathbf{e}_{yij} + \mathbf{f}_{y0j} + \beta_{ytj}\mathbf{Kind\_of\_Literacy\_Objective}_{yij} + \beta_{yuj}\mathbf{Digital\_Text\_Tool\_Selection\_Characteristics}_{yij} + \beta_{yvj}\mathbf{Integration\_Characteristics}_{yij} + \beta_{yzj}\mathbf{Interactions}_{ij} \quad (1)$$

The student outcomes of lesson *i* by student *j* had grand mean intercepts β_{00} and unexplained components (*residuals*) at the lesson- and student-levels, $\mathbf{e}_{ij}$ and $\mathbf{f}_{0j}$, respectively. First, kinds of literacy objectives were entered: *emergent literacy, word study, comprehension, fluency,* and

multimodal composing (**Kind_of_Literacy_Objective**). Next, PTs' characteristics of digital text or tool selections were entered: *quality of digital features for supporting literacy development, intuitiveness, interactivity* (**Digital_Text_Tool_Selection_Characteristics**). Note that *content* was not included in the analysis due to lack of variance (i.e., all scores were 2 – accurate or no content). Then, PTs' characteristics of instructional integration were entered: *modeling a transcendent literacy skill or strategy, guiding a transcendent literacy skill or strategy*, *modeling the use of a digital feature to support a transcendent literacy skill or strategy*, *guiding students' use of a digital feature to support a transcendent literacy skill or strategy,* and *capitalizing on digital features to transform instruction* (**Integration_Characteristics**). Then, interactions among the above significant explanatory variables were tested (**Interactions**).

An alpha level of .05 was used for all analyses. Testing many hypotheses increases the likelihood that at least one of them incorrectly rejects a null hypothesis (a false positive). To control for the false discovery rate, the two-stage linear step-up procedure was used, which outperformed 13 other methods in computer simulations (Benjamini, Krieger & Yekutieli, 2006). The statistical power differs at each level. For a 0.3 effect size at $p = .05$, statistical power was .82 for the 88 lessons, but only .47 for the 39 participants. Therefore, non-significant *participant-level results* must be interpreted cautiously (Konstantopoulos, 2008). See Appendix A, Table A1 for sample size and statistical power analysis.

Results

Summary Statistics

Digital text or tool selection. PTs' digital text and tool selections predominantly aligned moderately or highly with the criteria for effective selection (see summary statistics, Table 1). All of PTs' selections had at least moderate or high alignment with criterion for *intuitiveness*. No

selections had low alignment with this criterion. Additionally, many PTs' selections had high alignment with the criterion for *quality digital features* for supporting literacy development (68%). Just 1% had moderate alignment and 31% had low alignment with it. Also, PTs' selections related to *interactivity* were often highly (41%) or moderately (40%) aligned with the criterion. Only 19% had low alignment with it. Examples of digital texts and tools that were selected, and their ratings, are presented in Table 2.

Digital text or tool integration. The majority of PTs' instruction was well aligned with the criteria for effective integration. PTs provided effective modeling for transcendent literacy skills or strategies (recall that these are those skills or strategies that transcend paper or digital contexts—e.g., inferring, connecting, etc.) aligned with the objective in 62% of lessons, and provided effective guided practice for this in 75% of lessons. Likewise, PTs provided effective modeling for their students' use of digital features (i.e., ability to use digital features to support meeting the transcendent literacy skill or strategy objective—e.g., activating a hotspot to support determining a vocabulary word meaning) aligned with the objective in 66% of lessons, and guided this in 64% of lessons.

Partially effective modeling and guided practice were more likely to occur for a transcendent literacy skill or strategy use (12% for modeling and 10% for guided practice) than for digital feature use (1% for modeling and 3% for guided practice). This may have been because modeling and guiding a transcendent literacy strategy (e.g., inference) was more complex than modeling and guiding digital feature use (e.g., how to activate a hotspot).

Ineffective modeling and guided practice were more frequent for digital feature use (33% and 33% respectively), than for transcendent literacy skill or strategy use (26% and 14%, respectively). By looking at the video examples, we deduced that this was because PTs were

more likely to not provide any instruction for digital feature use, resulting in it being coded as *ineffective*.

PTs had the most difficulty *capitalizing on the digital features to transform instruction*. Just 31% of PTs' integrations reflected high quality teaching for this criterion, 25% reflected partially effective teaching, and 44% reflected ineffective teaching. This seemed to be the area of greatest difficulty for PTs in this study.

Student outcomes. Overall, the lessons were moderately effective in terms of students' outcomes. At the end of the lesson, 38% of students were able to use the transcendent literacy skill or strategy *independently*, and 50% were able to use the digital feature *independently*. Likewise, 51% of students were able to use the transcendent literacy skill or strategy *with teacher support*, and 25% were able to use the digital feature *with teacher support*. It seemed reasonable that it might take longer than one lesson for students to achieve independence with the more complex transcendent literacy strategies (e.g., inference). This potentially explains the lower percentage of students' independent use for transcendent literacy skills and strategies as compared to digital features, and the higher percentage of students who needed teacher support to be successful with transcendent literacy skills and strategies. However, some students were still unable to use transcendent literacy skills or strategies (11%) or digital features (25%) at the end of the lesson. The connections between these results and PTs' digital text and tool selection and integration characteristics were explored fully through the explanatory model.

Explanatory Model

The following results describe the significant findings from the final regression model, which describes what factors are related to (1) students' transcendent literacy skill or strategy outcomes (recall that these are those skills or strategies that transcend paper or digital contexts—

e.g., inferring) and (2) students' digital feature use outcomes (i.e., ability to use digital features to support meeting the transcendent literacy skill or strategy objective—e.g., activating a hotspot to support making an inference). Figure 3 presents a visual overview of the multivariate, multilevel logit model's results. The first column presents the statistically significant lesson objective variables (emergent literacy and word study). The second column presents the statistically significant digital text or tool selection variable (interactivity). The third column presents the statistically significant instructional integration variables (guiding a transcendent literacy skill or strategy, guiding the students' use of a digital feature, and *not* modeling a transcendent literacy skill or strategy). The fourth column presents the interaction effects. The fifth column presents the lesson outcomes: transcendent literacy skill or strategy use and digital feature use. The arrows in the figure show the relations between the variables and outcomes. The thickness of the arrow lines show the different effect sizes of the relations between variables. Thicker lines represent larger effect sizes. Note that students' transcendent literacy skill or strategy outcomes did not significantly vary among participants, but significantly varied across kinds of literacy objectives. In contrast, students' digital feature use outcomes varied significantly across both participants and objectives (see Appendix A, Table A2 for correlation, variance, and covariance matrices; ancillary regressions and statistical tests are available upon request).

Students' transcendent literacy skill or strategy use outcomes. Digital text or tool selection characteristics, instructional integration characteristics, and kinds of literacy objectives were all linked to students' transcendent literacy skill or strategy outcomes (see Table 3, top).

First, students had better transcendent literacy skill or strategy outcomes when (a) the digital texts or tools selected had greater *interactivity*, (b) PTs provided better *guided practice* for transcendent literacy skills or strategies, or (c) *emergent literacy* or *word study* objectives were

being taught. Some of these findings were illustrated in an emergent literacy lesson taught by Ms. Mandy that focused on Alejandro learning to identify the letter "p" both visually (in a word) and by sound (a picture whose name began with /p/). To facilitate this objective, Ms. Mandy selected the highly interactive app book, *Hop on Pop* (i.e., score 2/2 for interactivity). It was highly interactive because Alejandro could press anywhere on the illustration or text and the app would label the picture or highlight the word and read it aloud. This helped Alejandro make connections between printed words that began with the letter "p" and the oral words that the app read aloud with the /p/ sound. After initially teaching Alejandro the letter "p" and its corresponding sound, Ms. Mandy guided him to press a word that began with "p" as she pointed to the letter "p" that they had written earlier. Alejandro pressed the word "painting." Next, Ms. Mandy asked Alejandro to find pictures that began with the sound /p/ as she repeated /p/, /p/. When Alejandro pressed the picture of the pink pajamas, the app displayed the words "pink pajamas" on the screen and read them out loud. To encourage Alejandro to find more examples of pictures that started with the /p/ sound, Ms. Mandy then asked Alejandro, "What about this one?" as she pointed to the puppy (i.e., score 2/2 for guided practice for a transcendent literacy skill). By the end of the lesson, Alejandro was able to independently identify both pictures and words that started with the /p/ sound (i.e., score 2/2 for transcendent literacy skill use).

Additionally, when PTs selected digital texts or tools that were more intuitive *and* provided more effective guided practice for digital feature use, students had better transcendent literacy skill or strategy outcomes. For example, Ms. Adrienne taught her student, Nancy, a word study objective—how to sort pictures into groups that have the same beginning sound. To do this, she used a highly intuitive web-based game, *Clifford, The Big Red Dog, Sound Match* (i.e., score 2/2 for intuitiveness). It was highly intuitive because the app prompted the child to "find the

words that begin with the same sound as the picture name," and "put them in the box." Also, there was an image of a megaphone that the child could press to hear the directions again. Further, when the student clicked on a picture, the app told the child the name of the picture. This provided additional support for identifying the initial word sound. During instruction, Ms. Adrienne guided Nancy's use of the drag and drop digital feature to sort the words (i.e., score 2/2 for guided practice for digital feature use). When Nancy had difficulty dragging a picture over to the box, Ms. Adrienne put her hand on top of Nancy's hand and helped her click and drag it. By the end of the lesson, Nancy independently sorted the pictures by their beginning sounds within the web-based game (i.e., score 2/2 for transcendent literacy skill use).

Finally, when PTs taught multimodal composing objectives *and* modeled the use of a digital feature, then students' transcendent literacy skill or strategy outcomes were better. For example, Ms. Kora taught Yesenia how to use the Doodlecast app to create a multimodal composition. She modeled how to use the digital features, such as showing Yesenia how to take a picture using the iPad camera and selecting it to include in the multimodal composition (i.e., score 2/2 for modeling the use of a digital feature). By the end of the lesson, Yesenia was able to use the Doodlecast app to create a multimodal composition that told a story about how she lost her tooth, which included the photographs she took along with other modes of meaning (i.e., score 2/2 for transcendent literacy strategy use).

Students' digital feature use outcomes. Digital text or tool characteristics, instructional integration characteristics, and kinds of literacy objectives were all linked to students' digital feature use outcomes (see Table 3, bottom).

First, when PTs (a) selected digital texts or tools that supported more *interactivity*, (b) provided more effective *guided practice for use of digital features*, (c) provided less *modeling of*

transcendent literacy skills or strategies, or (d) taught *emergent literacy* or *word study* objectives, students had better digital feature use outcomes. Some of these findings were illustrated in the example presented previously, in which Ms. Adrienne and Nancy worked on sorting beginning picture sounds using the web-based game *Clifford, The Big Red Dog, Sound Match*. In this example, the web-based game was highly interactive (i.e., score 2/2 for interactivity). It let the child know whether or not they were correct when they dragged the pictures into the beginning sound box. If the child correctly sorted by beginning sound, the app accepted the item into the box and the child then heard Clifford bark. Inaccurate sorting resulted in the app moving the picture back to its starting position. During the lesson, Ms. Adrienne guided Nancy's use of the drag and drop digital feature to sort the words (i.e., score 2/2 for guided practice for digital feature use). Recall that when Nancy had difficulty dragging a picture over to the box, Ms. Adrienne put her hand on top of Nancy's hand and helped her click and drag it over the box and then release the mouse. By the end of the lesson, Nancy showed that she was able to use this digital feature (drag and drop) independently to support meeting the transcendent literacy skill or strategy objective (i.e., score 2/2 for digital feature use).

Additionally, when PTs were teaching word study objectives *and* modeled digital feature use, students' digital feature use outcomes were better. For example, Ms. Katherine used a web-based long and short vowel sort to teach De'Mario to differentiate these patterns. Ms. Katherine modeled how to click on the picture and drag and drop it into the correct pattern category (score 2/2 for modeling the digital feature use). After Ms. Katherine's effective modeling, De'Mario was able to click, drag, and drop the items into the shopping cart on his own (i.e., score 2/2 for digital feature use).

In contrast, when PTs were teaching word recognition objectives *and* provided more effective guided practice for transcendent literacy skills or strategies, students had worse outcomes for digital feature use. For example, Mr. Kent taught Jacob a word study objective that focused on how to use an online dictionary to help identify meanings for unfamiliar words while reading. Mr. Kent provided effective guided practice for Jacob regarding how to determine the word meaning by using the dictionary definition (i.e., score 2/2 for guided practice of the transcendent literacy skill). However, Jacob was unable to use important digital features, such as the hyperlinks within the dictionary definition without Mr. Kent's help (i.e., score ½ for digital feature use).

Moreover, PTs' more effective capitalization on digital features to transform instruction *combined* with more effective modeling of transcendent literacy skills or strategies was linked to students' better digital feature use outcomes. These findings are illustrated by a lesson in which Ms. Susie taught Anthony to make inferences using the Doodlecast app. Ms. Susie effectively capitalized on the digital features of the Doodlcast app to transform the three-step inference process (as compared to how it could be done with paper and pencil tools). First, she had Anthony use the camera function to capture clues in the illustration of the text. Second, she had him use the drawing function to illustrate his prior knowledge. Third, she had him write his inference (i.e., score 2/2 for capitalizing on digital features). Further, she modeled how to make an inference while thinking out loud. She explained that even though the inference was not stated in the text, you could use clues in the book and prior knowledge to infer. Then she demonstrated how she inferred that "the children were having fun with their imaginations" (i.e., score 2/2 for modeling a transcendent literacy strategy). After this, Anthony was able to use the digital features

during the inference task independently (i.e., score 2/2 for digital feature use). He took a picture of clues in the text, drew his prior knowledge on the screen, and audio-recorded his inference.

Discussion

Our study contributes to the international discussion about the complex relations amongst literacy, technology, and learning by showing how digital text and tool selections and integration are related to transcendent literacy skill or strategy use and digital feature use. In the following sections, we discuss how our findings contribute to the existing body of research on teachers' digital text and tool selection and integration. We also draw implications for teacher preparation and development.

Digital Text and Tool Selections

This research was the first to show characteristics of PTs' digital text or tool selections *across multiple research-based criteria*. PTs were best at selecting high *quality* digital texts or tools that had features to support meeting the transcendent literacy skill or strategy objective (68% of PTs scored 2/2). Likely, these fairly high scores were due to PTs' preparation for selection in their literacy course, which was similar to that provided in another study in which teachers had similar outcomes after similar professional development (Hutchison & Woodward, 2018). Additionally, other previous research also found that teachers improved their digital text or tool selection with professional development (Fernholz, 2014; Hutchison & Colwell, 2016; Kaalberg, 2014).

Further, our research extended previous findings that focused on whether or not the digital text or tool aligned with the instructional objective (Fernholz, 2014; Hutchison & Colwell, 2016; Kaalberg, 2014) by also exploring what specific selection criterion PTs used. Findings showed that the PTs in this study were least effective at selecting digital texts or tools that were *intuitive*

(only 35% of PTs scored 2/2) or had high user *interactivity* (only 41% of PTs scored 2/2). Given that both *intuitiveness* and *interactivity* of the digital texts or tools that PTs selected were significantly related to students' transcendent literacy skill or strategy outcomes, and *interactivity* was also significantly related to digital feature use, these may be areas of focus for improving PT preparation. To address these, it may be helpful to provide PTs with opportunities to identify, view, and score apps across the DigiLit Framework criteria, and discuss these scores to promote a shared understanding of each criterion. Additionally, as a guide for PTs, it may be useful to create a resource that lists digital texts and tools and identifies what gradation for each selection criterion is met on the DigitLit Framework.

Instructional Integration

To extend previous studies that showed 50-66% of teachers' digital texts or tool integrations in literacy instruction were rated as *advanced* or *meaningful* after professional development (Hutchison & Woodward, 2018; Paratore et al., 2016; Woodward & Hutchison, 2018), this study disaggregated the specific characteristics of instruction to identify which were most and least effective for this group of PTs. Findings showed that while more than a majority of PTs modeled and guided transcendent literacy skills or strategies (62% and 75% of the time, respectively) and digital feature use (66% and 64% of the time, respectively), just 31% of PTs *capitalized on* the *digital features to transform learning.* This is striking, given that 68% of PTs selected high *quality* digital texts or tools that had features to support the objective. That is, while PTs selected a tool that *could* be used to transform instruction, they often did not harness the digital features in a way that *did* transform instruction. This highlights another potential area to consider in better addressing PT preparation. For example, more explicit connections between

selection and instructional planning, such as explicitly articulating how the digital features will be used to transform instruction, might need to be added to the lesson plan template.

Further, while many PTs provided modeling and guided practice for using digital features well, 33% of PTs provided ineffective modeling and guided practice for using digital features, or did not provide modeling at all. To address this, further emphasis may be needed in PT development on addressing the modeling and guiding digital features use during instruction. One way to do this might be to include it explicitly in the lesson plan template (e.g., *When and how will you provide modeling and guided practice for using the digital feature/s and how will they transform instruction?*). Another way might be to have PTs practice modeling and guiding one another to use the digital features in new apps that they find. Additionally, further focus on these elements of instruction may be needed during video-based discussions.

Interrelations amongst Digital Text or Tool Selection, Integration, Objectives, and Student Outcomes

The results of this study underscored the importance of PTs (a) selecting highly interactive tools, as this supported both better literacy skill or strategy outcomes *and* digital feature use outcomes; and (b) providing effective guided practice to support both literacy skill or strategy *and* digital feature use outcomes.

Also, results provided clearer understandings about how PTs' digital text or tool selection, integration, and kinds of objectives intersected. For example, findings showed the importance of PTs (a) modeling digital features when they taught multimodal composing and word study objectives, (b) guiding students to use digital features to magnify the positive effects of selecting intuitive texts or tools, and (c) modeling literacy skills or strategies to capitalize on the use of digital features to transform instruction. Additionally, when PTs effectively modeled a literacy

skill or strategy, it detracted from students' use of digital features in the same lesson. It may be that the greater time spent on the transcendent literacy skill or strategy in the lesson detracted from the time spent on the digital feature use. In sum, aspects of selection or instruction that are most important may be nuanced, depending on the primary instructional objective.

Further, findings suggested that in one lesson of instruction a student was most likely to improve word study or emergent literacy skills or strategies, or digital feature use related to these objectives, as compared to attaining other objectives (e.g., multimodal composing or comprehension). There were several reasons why emergent literacy and word study objectives may have had better student outcomes as compared to other objectives. First, students' digital feature use outcomes were better for emergent literacy objectives and word study objectives than for other objectives, so this might have contributed to students' better skill or strategy outcomes for these objectives too. It may have been that digital features were easier to use for these objectives (e.g., drag and drop pictures to sort words by initial sound), as compared to the features available for other objectives (e.g., using a camera to take photos of clues to support inferences in text and uploading them into the app). Second, it may be that the emergent literacy and word study objectives were easier to achieve in one lesson as compared to other objectives. For example, if the emergent literacy objective was to sort words by their beginning sound, this might have been easier to learn in a lesson as compared to learning to use clues from text and prior knowledge to make an inference—a common comprehension objective. Third, it could have been some combination of the first and second reasons that explain our findings. It is important to note that we *do not* interpret these findings as showing that digital texts or tools work well only to support word study and emergent literacy objectives.

Limitations and Future Research Directions

There are four important limitations in our study, each of which are related to suggestions for future research. First, our participant sample of PTs was from methods classes at one university. Students across the methods classes had the same instruction on digital text or tool selection and integration. Also, they had access to similar digital resources including iPads and laptops. It would be useful to explore these issues using a broader sample of teachers from different areas across the world, who have more or less instruction about digital text and tool selection and integration, more varied access to different resources, and who represent different cultural and socio-economic backgrounds.

Second, we looked at PTs' selection and instruction, and student outcomes for just one or two of PTs' best lesson(s) from across a semester—i.e., a moment in time. Future research should also explore PTs' and students' development and outcomes across time.

Third, we knew from talking with the children in this study that they did not have iPads at home, or experience with the apps used for instruction. However, future research should more explicitly collect data regarding students' technology knowledge and experience prior to their instructional lessons with PTs, as it may affect their performance during lessons.

Finally, our data did not explain *why* PTs made the choices they did for digital text or tool selections and integration. Future research should use post-instruction interviews or retrospective video recall to better understand PTs decision-making. This might also provide insights into whether searching skills, evaluation skills, or funding/access (e.g., purchase, free, school subscription) contribute to PTs' selection quality, which could better guide the most appropriate solutions.

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Table 1.
Summary statistics (N = 88)

	Percentage of data at each value		
Variable	**0 Unable to use**	**1 Use with Teacher Support**	**2 Use Independently**
Student outcomes			
Literacy skill or strategy use	11	51	38
Digital feature use	25	25	50
Variable	Mean (% of all objectives)	Min	Max
Lesson objectives			
Emergent literacy	6	0	1
Word study	31	0	1
Fluency	5	0	1
Multimodal composing	5	0	1
Comprehension	53	0	1
	Percentage of data at each value		
Digital text or tool selection quality	**0 Low Quality**	**1 Moderate Quality**	**2 Good Quality**
Digital tool or text quality	31	1	68
Navigation tool intuitiveness	0	64	35
User interactivity	19	40	41
Instruction quality	**0 Ineffective Teaching**	**1 Partially Effective Teaching**	**2 Effective Teaching**
Modeling literacy skill or strategy	26	12	62
Guided practice of literacy Skill or strategy	14	10	76
Modeling digital feature use	33	1	66
Guided practice for digital feature use	33	3	64
Capitalizing on digital features to meet lesson objective	44	25	31

Note. Standard errors in parentheses; Each regression model included a constant term. *$p < .05$, **$p < .01$, ***$p < .001$

Table 2.

Examples of PTs' Digital Text or Tool Selections and Their DigiLit Rubric Ratings

Digital Text or Tool Name	Description	Digital Text or Tool Quality Score	Intuitive-ness Score	Inter-activity Score
Online Dictionary	Students look up definitions of unknown words to help build comprehension.	0	1	1
Popplet Online Tool	Students use this online tool to mind-map. Words and pictures can be inserted into "Popples" to retell, gather facts and show relationships.	0	1	1
ReadWriteThink Notetaker Online	This tool allows students to organize their thinking and take notes digitally. Students can enter up to 5 levels of information about reading and writing activities.	0	1	0
Online Search Engines	Search engines allow students to look up and gain information on a particular topic.	2	1	2
Sound Match Online Game	Students identify initial consonants and match letter sounds to their corresponding letters. Students have to find the words that begin with the same sound as the picture name and drag them into a box.	2	1	1
Inference Clues App	Students learn to identify the clues that lead to an inference and also identify which inference comes from specific clue words.	0	2	1
Mutlisyllabic App	This app shows a puzzle cut into two pieces with a chunk of a word on each piece. The app reads each chunk as the puzzle pieces slide away to reveal a portion of the picture that represents a word.	2	2	1

Popplet App	Students use this app to mind-map. Words and pictures can be inserted into "Popples" to retell, gather facts and show relationships.	0	1	1
Sight Word Puppy Dash App	Students practice high frequency words by clicking on the word that is read aloud.	0	1	1
Starfall Read to Learn App	Students match letters and sounds including short and long vowels, and chunks of words.	2	2	1
Raz Kids Story-Carlos and his Teacher (Web-based digital Text)	This story can be read by the website in both English and Spanish to the student.	2	2	1
Ratatouille (Web-based digital Text)	PDF version of the story online.	0	2	0
Sheep in a Jeep (Web-based digital Text)	The story is read aloud to the student.	2	2	0
Dr. Seuss Collection (app books)	The child can choose to read aloud, use the read to me feature, or press particular words that they need help with. It also contains hotspots to increase comprehension.	2	1	1
Ocean Oddities (app book)	The child can choose to read aloud, use the read to me feature, or press particular words that they need help with. It also contains hotspots to increase comprehension.	2	2	1

Table 3.
Summary of 6 multivariate, multilevel logit models for students' outcomes

	Model 1	Model 2	Model 3	Model 4	Model 5
	Objective	+ Digital Tool / Text	+ Instruction	+ Interactions	Reduced[a]
Explanatory variable	Students' literacy skill or strategy use outcomes				
Emergent literacy skill objectives	0.721**	0.667*	0.790**	0.600**	0.550**
	(0.259)	(0.297)	(0.228)	(0.190)	(0.185)
Word study objectives	0.321	0.445**	0.507**	0.340*	0.309*
	(0.195)	(0.164)	(0.147)	(0.159)	(0.153)
Fluency objectives	0.637	0.601	0.429	0.317	
	(0.353)	(0.316)	(0.246)	(0.258)	
Multimodal composing objectives	0.637*	0.530	0.517**	0.029	-0.006
	(0.240)	(0.269)	(0.180)	(0.152)	(0.158)
Digital tool/text quality		0.136	-0.033	-0.072	
		(0.085)	(0.098)	(0.095)	
Digital tool/text intuitiveness		0.215	0.100	0.068	0.063
		(0.127)	(0.145)	(0.149)	(0.125)
Digital tool/text interactivity		0.214*	0.342***	0.222*	0.283***
		(0.088)	(0.087)	(0.090)	(0.068)
Capitalizing on digital features during instruction			0.131	0.183	
			(0.123)	(0.142)	
Modeling digital feature use during instruction			-0.061	0.094	0.079
			(0.092)	(0.085)	(0.089)
Guided practice for students' digital feature use during instruction			-0.178	-0.230	-0.142
			(0.107)	(0.133)	(0.077)
Modeling a transcendent literacy skill or strategy during instruction			0.062	0.026	0.042
			(0.115)	(0.103)	(0.103)
Guided practice for students' use of a transcendent literacy skill or strategy during instruction			0.479**	0.570***	0.565***
			(0.147)	(0.115)	(0.121)
Multimodal composing objective				1.236 ***	1.145***
* Modeling digital feature Use				(0.224)	(0.229)
Digital text or tool intuitiveness				0.462 **	0.466**

* Guided practice for students' digital feature use				(0.167)	(0.160)
Variance at each level	Explained variance at each level				
Participant (0%)	0.000	0.000	0.000	0.000	0.000
Objective (100%)	0.141	0.222	0.453	0.548	0.480
Total variance explained	0.141	0.222	0.453	0.548	0.480
	Students' digital feature use outcomes				
Emergent literacy objective	0.764	1.152*	0.955	0.891*	0.684**
	(0.590)	(0.463)	(0.413)	(0.347)	(0.246)
Word study objective	0.161	0.638	0.491	0.538	0.389**
	(0.451)	(0.386)	(0.331)	(0.275)	(0.143)
Comprehension objective	0.029	0.136	0.075	0.082	
	(0.433)	(0.369)	(0.309)	(0.260)	
Multimodal composing objective	0.554	0.440	0.501	0.587	
	(0.574)	(0.495)	(0.413)	(0.351)	
Digital text or tool quality		0.021	-0.148	-0.157	
		(0.117)	(0.108)	(0.090)	
Digital text or tool intuitiveness		-0.156	0.137	0.100	
		(0.215)	(0.202)	(0.175)	
Digital text or tool interactivity		0.681***	0.569***	0.454***	0.389***
		(0.150)	(0.132)	(0.117)	(0.110)
Capitalizing on digital features during instruction			0.010	0.015	-0.027
			(0.101)	(0.088)	(0.085)
Modeling digital feature use during instruction			0.131	0.169	0.122
			(0.107)	(0.097)	(0.092)
Guided practice for students' digital feature use during instruction			0.334**	0.341**	0.332**
			(0.117)	(0.099)	(0.102)
Modeling a transcendent literacy skill or strategy during instruction			-0.079	-0.148	-0.170*
			(0.088)	(0.076)	(0.079)
Guided practice for students' use of a transcendent literacy skill or strategy during instruction			0.176	0.192	0.175
			(0.116)	(0.100)	(0.103)
Word study objective				0.570***	0.590***
* Modeling digital feature Use				(0.135)	(0.142)

Word study objective				-0.878***	-0.834***
* Guided practice for students' use of a transcendent literacy skill or strategy				(0.205)	(0.215)
Capitalizing on digital features				0.189*	0.167*
* Modeling a transcendent literacy skill or strategy				(0.082)	(0.083)
Variance at each level	Explained variance at each level				
Participant (39%)	0.178	1.000	1.000	1.000	1.000
Objective (61%)	0.021	0.151	0.428	0.604	0.559
Total variance explained	0.083	0.485	0.653	0.760	0.733

Note: Each model includes a constant term (intercept). *p < .05, **p < .01, ***p < .001
[a] The reduced model contains only the required significant explanatory variables or components of significant interactions

Figure 1. *Scoring for Characteristics of Digital Text or Tool Selection (based on the DigiLit Framework;* Baxa & Christ, 2018)

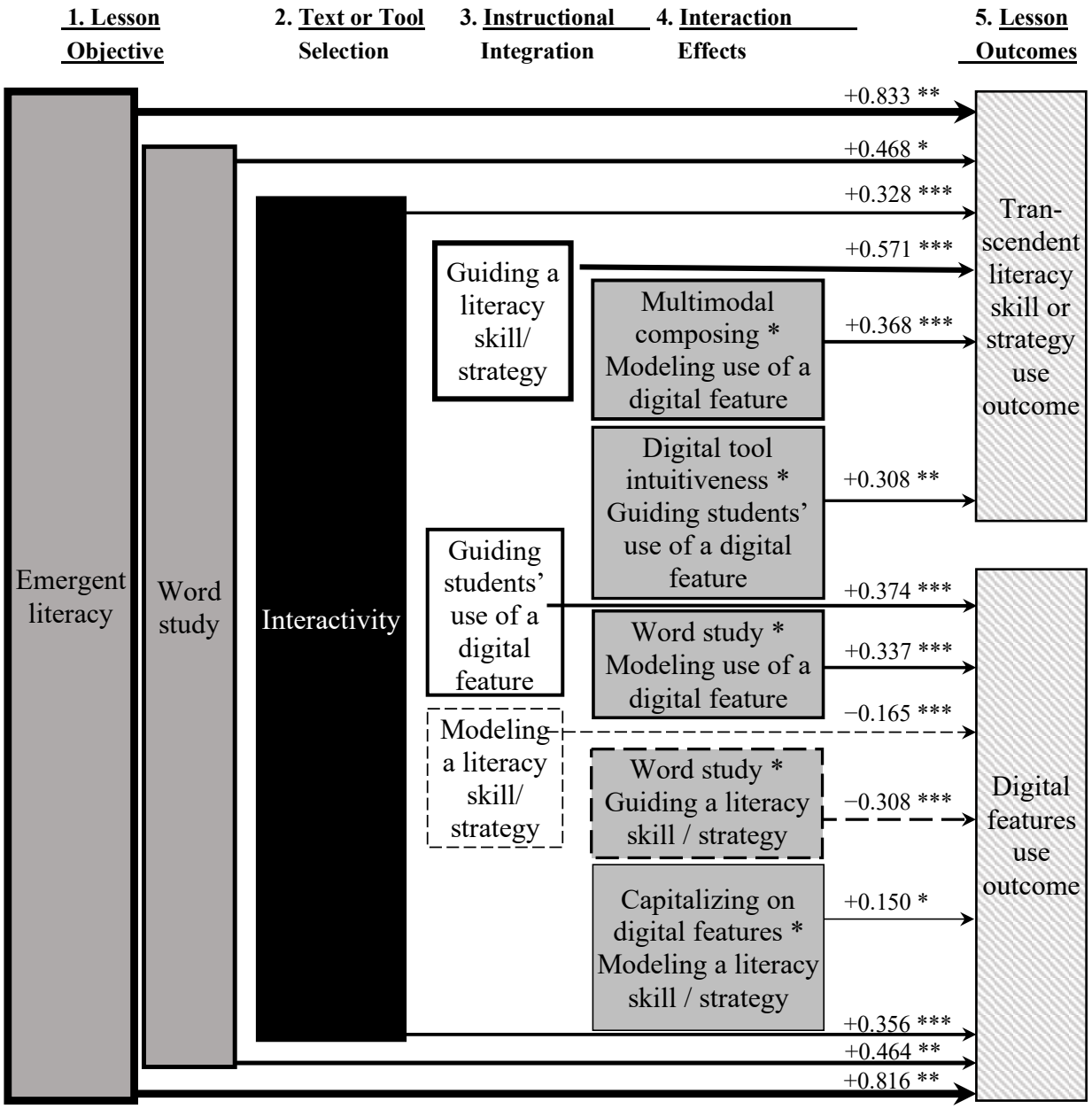
	2 – Good Quality	1 – Moderate Quality	0 – Low Quality
Literacy Content	Provides accurate content (e.g., letters, phonemes, etc.) **NA-** literacy content is added by the user	Has inaccuracies, but they do not inhibit learning	Has inaccuracies that potentially disrupt or inhibit literacy learning
Quality	**Text Quality**: High-quality continuous text AND has features that support processing beyond what is possible with paper **Tool Quality**: Digital features support processing in ways beyond what is possible with paper/pencil tools		**Text Quality**: Text without additional digital features OR Text with digital features that are not authentic/ continuous **Tool Quality**: Digital features do not support processing in ways beyond what is possible with paper/pencil tools OR only provide opportunity for entertainment
Intuitiveness	**Intuitive -** Tasks and options within digital tool clearly displayed, easily used; offers user cues (symbols, etc.) for next steps; offers illustrative example of how to use digital tool	**Somewhat Intuitive** Some cues or symbols may be slightly unclear; may have pop-ups.	**Confusing -** Numerous pop-ups; unclear how to start activity once digital tool is launched/opened.
Interactivity	**High Interactivity** - Features support high interactivity OR content may be changed/ manipulated by user, allowing more creativity and expression	**Moderately Interactivity -** Task is minimally interactive OR user cannot change or alter content	**No Interactivity** - No interactions are possible OR the teacher controlled the technology so child never had the opportunity to interact

Figure 2. *Scoring for Characteristics of Digital Text or Tool Integration in Instruction (based on the DigiLit Framework;* Baxa & Christ, 2018)

	2 – Effective Teaching	**1 – Partially Effective Teaching**	**0 – Ineffective Teaching**	**Not Applicable (NA)**
Model a Literacy Skill or Strategy	Provides effective, explicit modeling of how to use the literacy skill or strategy.	Modeling does not clearly present how to engage in the literacy skill or strategy. OR Questions the student for input rather than modeling.	No evidence of modeling the literacy skill or strategy (e.g., teacher may provide an explanation, but not an example of its application).	The student interrupts the modeling to participate, and the teacher then shifts to guided practice.
Guide Students' Use of the Literacy Skill or Strategy	Use of the literacy skill or strategy is effectively gradually released to the student with appropriate support.	The teacher tries to guide the student, but the support is not appropriately adjusted to the student's needs so that it is effective.	No evidence of guidance for the student's engagement in the literacy skill or strategy.	The student can engage with the literacy skill or strategy immediately and there is no need for guided practice.
Model the Use of Digital Feature	Provides effective, explicit modeling of how to use the digital features of the text or tool being used.	Modeling does not clearly present how to use the digital features effectively. OR Questions the student for input rather than modeling use of the feature.	No evidence of modeling the digital feature (e.g., teacher may provide an explanation of how to use the feature, but doesn't show its effective use).	The student interrupts the modeling to participate, and the teacher then shifts to guided practice.
Guide Students' Use of the Digital Feature	Use of the digital feature is effectively gradually released to the student with appropriate support.	The teacher tries to guide the student, but the support is not appropriately adjusted to the student's needs so that it is effective.	No evidence of guiding the use of the digital feature	The student can engage with the digital feature immediately, and so there is no need for guided practice.

Capitalize on Digital Features to Transform Instruction	**Modification** - same literacy *task* but *different processing* than paper OR **Redefinition -** different literacy *task* and *processing* than paper	**Augmentation** - same literacy *task* and *processing* as paper with additions to content	**Substitution -** same literacy *task* and *processing* as paper with no additions to content, OR has features but these *weren't used*	

Figure 3. *A path diagram showing the explanatory model for students' outcomes. Solid lines indicate positive links. Dashed lines indicate negative links. Thicker lines indicate larger links. *p < .05, **p < .01, ***p < .001.*



Appendix A
Ancillary Tables and Results

Table A1
Sample size and statistical power

	Effect size			
Level	0.1	0.2	0.3	0.4
2) Participant	.08	.23	.47	.73

Table A2
Correlations, Variances, and Covariances are along the Lower Left Triangle, Diagonal, and Upper Right Triangle of the Matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1	**0.429**	0.256	0.032	0.036	0.020	-0.023	0.084	0.034	0.218	0.223	0.032	0.130
2	0.469	**0.691**	0.056	-0.034	0.026	-0.157	0.365	-0.018	0.177	0.395	0.355	0.528
3	0.203	0.277	**0.059**	-0.020	-0.003	-0.003	0.008	-0.013	0.005	0.016	-0.021	0.043
4	0.119	-0.089	-0.174	**0.215**	-0.015	0.048	-0.164	-0.001	0.009	-0.063	-0.071	-0.035
5	0.146	0.149	-0.057	-0.150	**0.045**	-0.014	0.029	-0.021	0.000	0.020	0.016	0.001
6	-0.076	-0.415	-0.026	0.226	-0.144	**0.209**	-0.205	-0.041	-0.028	-0.215	-0.269	-0.218
7	0.169	0.578	0.042	-0.466	0.182	-0.590	**0.578**	-0.045	0.029	0.328	0.330	0.336
8	0.065	-0.027	-0.065	-0.003	-0.124	-0.110	-0.073	**0.654**	0.102	0.121	0.273	0.124
9	0.501	0.320	0.030	0.029	-0.002	-0.091	0.058	0.190	**0.439**	0.316	0.139	0.274
10	0.345	0.482	0.066	-0.137	0.094	-0.478	0.438	0.152	0.485	**0.969**	0.418	0.625
11	0.053	0.456	-0.090	-0.164	0.080	-0.629	0.464	0.361	0.224	0.454	**0.877**	0.538
12	0.212	0.681	0.190	-0.081	0.005	-0.511	0.473	0.164	0.444	0.680	0.616	**0.871**

Note. 1) Students' literacy skill or strategy use outcomes, 2) Students' digital feature use outcomes, 3) Emergent literacy objectives, 4) Word study objectives, 5) Multimodal composing objectives, 6) Digital text or tool intuitiveness, 7) Digital text or tool interactivity, 8) Modeling a literacy skill or strategy, 9) Guided practice for students' use of literacy skill or strategy, 10) Capitalizing on digital features in instruction, 11) Modeling digital feature use, 12) Guided practice for students' digital feature use