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A critical analysis of technology's impact on teacher's views of literacy learning and teaching: A continuum of understandings

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Keeping Student Personality Types in Mind: Online vs. Face-to-Face Discussions

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Over the past few years, technology has increasingly been implemented to enrich teaching and learning experiences (Paechter, Maier, & Macher, 2010). In addition to creating a more dynamic classroom, improvements in technology and decreased costs have led to an increase in online and blended classrooms. These types of online classrooms are of greater convenience and make higher education more accessible for distance learners (Harrington & Loffredo, 2010). As a college level professor, it is essential to begin increasing the use of technology in the classroom in a variety of ways in order to facilitate accessibility, develop convenience, and enrich the learning experiences of students. Utilizing technology in the classroom is important in creating an interactive and engaging learning experience. Although there are multiple benefits to online learning, it is important to note that a large percentage of students continue to prefer face-to-face classes (Harrington & Loffredo, 2010). For some, the belief that more is learned in face-to-face classes than online classes is a common research finding. It comes into question what continues to influence this preference.

Psychological factors such as personality type may impact learning style, comfort level, and motivation in learning environments (Harrington & Loffredo, 2010). It is hypothesized that not everyone can perform all tasks as effectively as one another. This reveals that personality traits play an essential role in performance of individuals completing the same tasks (Ahmed, Campbell, Jaffar, & Alkobaisi, 2010). Personality types can create a great deal of diversity in the performance of various activities and tasks that individuals do. Additionally, personality impacts the way people perceive their environment, create meaning, and make decisions in the world. It has been noted in previous research that people with particular learning styles and personality types are more inclined to failure in online learning environments (Harrington & Loffredo,

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2010). For example, DiTiberio (1996) concluded that extraverts typically prefer collaborative learning environments whereas introverts prefer and do well with computer-assisted instruction. In a study done by Harrington and Loffredo (2010), it was found that introverted individuals preferred online classes and extraverted individuals preferred face-to-face classes. Therefore, it can be hypothesized that introverts would prefer and excel more in online learning than in face-to-face.

Theory

Motivation reflects investment in cognitive, emotional, and behavioral engagement and interest in school (Fredricks, Blumenfeld, & Paris, 2004). However, motivation has traditionally been seen through an intrapsychological lens. Most theories related to motivation place an individual as the agent who processes information and presents feelings related to motivation. However, it is important to note that learning often occurs most in sociocultural contexts (Vygotsky, 1978). Therefore, conceptualizing motivation through the lens of social constructivist, based on the work of learning as a cognitive construct (Piaget, 1950) is essential for this study. Social constructivist theory suggests that the individual is not the instigator of motivation; rather motivation is socially constructed and results in cognitive and behavioral engagement (Sivan, 1986).

Social constructivism theory is a shift towards viewing the construction of meaning through the interaction of individual with context (Sivan, 1986). The components of social constructivist theory include cognitive activity, cultural knowledge, tools and signs, and assisted learning. For this particular study, the assisted learning component will be the main focus and this is the approach to social construction that will be used. Assisted learning is a process of

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socialization, occurring through the construction of shared understandings in the environment. Assisted learning is described as the movement of inter-psychological functioning to intrapsychological functioning, resulting in a shared construction of meaning and understanding (Sivan, 1986). According to this theory, learning occurs when students share background knowledge and participate in the reciprocation of information, collaboration, and activities in order to achieve highest potential of learning (Sthapornnanon, Sakulbumrungsil, Theeraroungchaisri & Watcharadamrongkun, 2009). In terms of the present study, assisted learning would be demonstrated through face-to-face literature circles where students interact and collaborate with one another to form a comprehensive understanding of the literature that was read.

With the ever-changing world of technology, it is important to consider how social constructivism theory may be implemented into an online learning environment. An online environment may be useful in stimulating slow thinkers, introverted personalities, and those who are reluctant to engage in face-to-face discussions (Sthapornnanon et al, 2009). Online communication provides students with more time to think about their responses and an equal opportunity to share their thoughts. This type of learning environment provides an opportunity for collaborative learning to be more inclusive of all students, therefore allowing all students to benefit, contribute, and learn from one another.

As noted above, it is apparent that socially constructed learning can occur in both face-to-face settings as well as online settings. However, it comes into question whether one setting is more beneficial or preferred than the other.

Method

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The findings above have led to questioning the pedagogical choices that are made in terms of meeting the needs of diverse learners, and in particular how motivation and student learning are related. The questions addressed are the following: 1) How do face-to-face literature circles and online literature circles impact motivation? 2) Is there a measurable difference in motivation based on personality type (extrovert vs. introvert) in relation to the type of literature circle utilized?

Instruments

As part of normal classroom activities, students explored their own personality traits through a Jung personality self-assessed survey. The Jung Typology Test is a personality assessment based on four criteria called dichotomies, which represent a continuum between two opposite poles. The four dichotomies are extraversion/introversion, sensing/intuition, thinking/feeling, and judging/perceiving. The first criterion, which is the focus of this study, is extraversion-introversion. This criterion signifies the source and direction of a person's energy expression. Specifically, an extrovert's source of energy is mainly from the external world, while an introverted individual finds their energy mainly from their own internal world.

Throughout the course, students participate in both face-to-face and online literature circle discussions. After each of these activities, students take an Intrinsic Motivational Inventory assessment to measure motivation to participate and learn in the literature circle. The Intrinsic Motivational Inventory is a multidimensional instrument intended to measure participant's subjective experience to a given activity. The instrument assesses participants based on their interest/enjoyment, perceived competence, effort, value/usefulness, felt pressure and tension, and perceived choice while performing a given activity.

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Students' measured personality styles (introvert vs. extrovert) were then compared to their motivation to determine what type of literature circle discussion helps improve student motivation for what type of student. In addition, students were given a survey at the end of the course asking for comments and preferences about both face-to-face and online literature group discussions.

Participants

Participants included 18 undergraduate students from a literacy course in a Midwestern university with 11,000 students. Participants consisted of twenty-one percent males (n=5) and seventy-two percent females (n=13), and were predominately Caucasian. All participants participated in all literature group discussions.

Results

Although extraverted individuals are more likely to strongly prefer face-to-face literature circles, it appears that both introverted and extraverted individuals typically are more motivated during face-to-face interactions. See Table 1. Specifically, extraverted individuals averaged a score of 4.913 for motivation during face-to-face literature circles and 3.909 for motivation during online literature circles. Extraverts' preference for face-to-face literature circles was found to be statistically significant with $t(18)=2.085$, $p < .05$. Introverted individuals averaged a score of 4.805 for motivation during face-to-face literature circles, and a 4.562 for motivation during the online literature circles. There was no statistical significance in the difference of preference for introverted individuals.

Overall, motivation was higher for all students regardless of their type in face-to-face literature circles. Students averaged a score of 4.871 in face-to-face motivation and a 4.163 in

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online literature motivation. When examining actual preference, only one participant stated that they preferred online literature circles, and one participant stated they had no preference. Therefore, 88 percent of the sample stated that they preferred face-to-face literature circles, even those whose motivation scores were higher in online literature circles.

Survey results from students show that students overwhelmingly found value in face-to-face opportunities. One student stated, "I liked how when we met face-to-face we could enjoy rigorous conversation and see facial expressions, and when we were done we were done. I did not enjoy the discussion boards because I felt like we could never end the conversation. I felt I had to continuously post for the sake of posting when nothing meaningful was left to say."

Another student discussed the length of conversations by stating, "I thought as groups we had better discussions face-to-face. Also doing face-to-face I personally was more likely to keep the discussion going compared to online where my answers were rather shorter." Finally, students provided insight into the connected aspect of the two opportunities with, "Face-to-face discussions, in this class anyway, were much more personable, and therefore there was an enhanced feeling of connectedness. We all share a lot more in face-to-face than online because there was a feeling of detachment when you all you could see is typed words." The comments from the survey corresponded directly to what was found in the IMI results.

Limitations

The overall findings of the study were both encouraging and positive. However, the study has several limitations. There was a small n and the participants in this study were predominantly Caucasian and female, making the sample lack diversity. Future studies may benefit from utilizing more diverse populations to increase external validity and generalizability. Additionally, due to the

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convenience of the sample, only education majors were selected for this study. There may be themes or commonalities in the findings related to personality type and motivation due to the nature of the type of people used for this study. In terms of future studies, further examination with a larger sample size of the relationship among motivation, preference, and personality type in relation to literature circle type would be important. The current study has created a foundation in which future research can build upon to fully understand social aspects that may influence the learning process.

Conclusion and Implications

Referencing to social constructivist theory, learning is socially constructed. Specifically, individuals learn through their contexts and environments as well as through their interactions with others. Based on the results of this study, it appears that overall participants are more motivated to participate and contribute to learning when they engage in face-to-face interactions, despite their personality style. Contrary to much research that has been done, personality traits may not be as much of a factor as previously thought in learning situations. Due to the lack of interpersonal interactions, immediacy, and expression in online literature circles, it can be suggested that motivation to learn occurs most when people are collaborating in person. This study provides an interesting perspective of the power of nature vs. nature in that the power of social construction overpowers personality traits.

Based on the findings, there are teaching and learning recommendations that can be considered. First, these findings can help students understand their learning style and what type of learning may be best suitable for them. This will help them as learners as well as future teachers. Additionally, educators need to take into account the impact that students learning styles and motivation have on student perception and participation in learning activities, but personality traits

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may not be as crucial. If students are not provided with learning opportunities that meet their needs, motivation becomes an issue and learning may be impacted. Teachers also need to provide opportunities for students to explore content in social face-to-face settings. This study directly pointed to the fact that these students clearly preferred face-to-face opportunities to learn with and from their peers. Finally, in online or hybrid courses, teachers should consider integrating Skype or Google Hangout as a way to make online discussions more engaging and interactive.

It is important to note that the majority of individuals stated they preferred face-to-face literature circles, even if their IMI scores were higher for online literature circles. It comes into question if comfort and perception of effectiveness impact participants' preference of literature circle. Additionally, since we know students are socially conditioned to expect face-to-face delivery methods in education, thought should be given to what types of encouragement, pedagogy, and assignment deign might trigger trigger alternate ways of understanding in online learning, so the online interaction is seen as equally, if differently, satisfying to students while still addressing motivation. It would be beneficial to conduct further studies that examine comfort level and perception of effectiveness of online and face-to-face literature circles as they relate to an individual's personality type with these factors in mind. Additionally, looking at this as a pilot study pointing to the need for more research looking at nature vs. nature and how social constructivism may overpower an individual's personality type would be justified.

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Appendix A

Table 1

Intrinsic Motivational Inventory Scores

	Number of Students	Personal Preference for Online Discussions	Personal Preference for Face to Face Discussions	No Personal Preference	IMI Average Score for Online Discussions	IMI Average Score for Face to Face Discussions
Introverts	**7**	**1**	**5**	**1**	**4.562**	**4.805**
Extroverts	**11**	**0**	**11**	**0**	**3.909**	**4.913**

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Universal Design for Learning: Examining Access Afforded by Children's Search Engines

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Abstract

Young children benefit from authentic opportunities to conduct online searches. Decisions related to the use of children's search engines versus universal search engines should include considerations for the affordances of technology that accommodate learner variability. Using Universal Design for Learning (UDL) as a framework for providing access to learning materials, this study includes an analysis of the affordances of search engines for both children and the general population. UDL, an inclusive framework for learning, leads contemporary efforts to create comprehensive access to educational curricula for *all* students, especially those with learning variabilities. The focus of our study is on one of UDL's principle, multiple means of representation for content access, and ways children's search engines address its guidelines of perception, language and symbols, and comprehension.

Keywords

Universal Design for Learning, multiple means of representation, affordances, technology, search engines

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Just as modern buildings are designed with elevators, ramps, automatic doors, and adaptive lighting for people of varying needs and abilities, internet search engines are continually updating and adapting with easier access to the vast amount of information housed and connected in that global repository. In 2019, the Pew Research Center reported that only 10% of U.S. adults do not use the internet, meaning 90% do (Anderson, Perrin, Jiang, & Kuman, 2019). Internet use in the home, workplace, and across all disciplines, requires a set of skills to navigate information, sort commentary from news, determine content from advertisements, identify biases and opinions, and discern source validity and reliability. These skills are required for research at every level, and therefore, must be addressed and taught to children. Explicit instruction of Web literacy skills aligns with research that supports exposure to online experiences at an early age to develop literacy skills (Baildon & Baildon, 2008; Leu, Forzani, Timbrell, & Maykel, 2015; Vasinda & Pilgrim, 2019). Leu, et al. (2015) suggested that schools “begin teaching and learning new literacies as early as possible” (p. 350). In other words, opportunities to conduct online searches are necessary, in the same way that opportunities to read books to and with young children are necessary. In addition, differentiation for learners in an online environment is necessary, just as differentiation occurs with other learning materials. The good news is that accommodating features, such as speech recognition and autocorrect, are increasingly a part of the search engine design. Just as with architectural access for all, these search engine accommodations are available to everyone. In this article, we share a study in which search engine features are analyzed using a framework called Universal Design for Learning.

Inspired and influenced by the Universal Design (UD) thinking of architectural access, Universal Design for Learning (UDL) is an inclusive framework for learning. Developed by

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David Rose and Ann Meyers of the Center for Assistive Special Technology (CAST), UDL leads contemporary efforts to create comprehensive access to educational curricula for *all* students, especially those with learning variabilities. *Universal* implies consideration for multiple access points to the same learning goals so that all students, regardless of their individual learning needs, can attain the same learning goal (Rose & Meyer, 2006). *Design* reflects intentional planning for multiple ways to access content and processes as well as multiple ways to represent understanding through various materials, formats, and assessments (Meyer, Rose, & Gordon, 2014). A one-size-fits-all mentality does not work for architectural design or learning design due to learner variability and diversity. UDL's theoretical framing reflects the notion that everyone can learn complex concepts through the support of effective scaffolds.

Theoretical Perspective

The UDL framework builds foundations of scaffolded learning and represents a shift in how we consider learner needs and differences. Rather than learners needing to adapt to the curriculum, this shift in thinking focuses on how the curriculum needs to adapt to the needs of the learners (Coyne, Ganley, Hall, Meo, Murray, & Gornan, 2007), much like the architectural features of a building are designed to meet the needs of all people. UDL claims Vygotsky's sociocultural theory, specifically scaffolding, as a theoretical framework. Although Vygotsky never used the term "scaffolding," a major feature of scaffolding is the interaction between a learner and another more knowledgeable person who can provide necessary assistance until the child can complete the task independently. This support is referred to as the Zone of Proximal Development (ZPD). ZPD represents the area of learning where scaffolding of new information is most effective and most likely to be learned (Vygotsky, 1978). Teacher support gradually

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diminishes as learners become more independent with the new concept or skill until it becomes part of their Zone of Actual Development (ZAD). Teachers who use UDL principles consider learners with language, reading, or writing variabilities, as well as physical variabilities when they plan instruction so that everyone has access to learning new content, concepts, and processes. Through UDL, teachers maximize student engagement and opportunities for learning by intentionally planning lessons and assessing learning by considering what students can do in the best of circumstances with the right tools and resources (Coyne, Pisha, Dalton, Zeph, & Smith, 2013).

UDL Principles and Technology Support

UDL includes three principles: Multiple Means of Engagement, Multiple Means of Expression, and Multiple Means of Representation. Multiple Means of Engagement, the *why* of learning, is the affective network that signifies ways interest and purpose engage and motivate learners (CAST, 2018). Multiple Means of Representation, the *what* of learning, is the recognition network that explains how content is represented and how information is processed by learners (CAST, 2018). Multiple Means of Expression, the *how* of learning, is the strategic network involving how learners monitor progress and demonstrate learning (CAST, 2018). UDL provides a framework of support and access for *all* learners to become self-directed and independent.

With advances in technology, UDL now promotes “taking advantage of the power and customizability of modern technology to deliver, by design, flexible instructional practices directly within the core instructional curriculum where students can access them on an individualized basis” (Lapinski, Gravel, & Rose, 2012, p. 7). Technology provides opportunities

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for UDL that extend beyond the scaffolding and support of learning. We propose that internet tools consistently provide accommodations and access for learners that need scaffolding, but they also provide conveniences that may appeal to anyone. These scaffolds and conveniences align well with UDL principles. The focus of our study is on children's search engines and how UDL's multiple means of representation are built into many search engines.

Multiple Means of Representation: Guidelines for Access

Search engines include unique features that enable users with various skills and abilities to access information on the internet. The affordances of search engines align with the UDL principle of multiple means of representation. Consider the learner who struggles to type due to a physical disability or a broken arm. The classroom teacher must consider ways to accommodate these learners. If assigned research on the internet, these learners may struggle to search the internet with the keyboard. Search engine features enable these learners to use speech-to-text (STT) tools during their search. The same may hold true for learners with spelling or language barriers. Built-in accommodations, like spell-check, STT, and translation capabilities, enable students to access information. Lesson design is critical for teachers to provide access for these learners.

CAST (2018) provides three guidelines to consider when it comes to the representation of content for all learners (Table 1). *Perception* is one of the three guidelines (CAST, 2018). Think back to the student with the physical disability or broken arm. These students needed opportunities to interact with flexible content that does not depend on a single sense. In other words, these students and others need options for sight, hearing, movement, or touch. *Perception,* as a guideline, is reflective of the idea that students need multiple access points.

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Search engines may provide a customized display of information, alternatives for auditory information, and alternatives for visual information.

Another guideline is *language and symbols* (CAST, 2018). This guideline involves communication through languages that create a shared understanding. Students with weak language and symbols skills might need teachers to clarify vocabulary, syntax, and structure or support the decoding of text or mathematical symbols. Teachers may also need to promote understanding across languages or across multiple modes of media. Think back to the struggling speller and the student with the language barrier; these students benefit from intentional design that enables them to access language. Search engines may provide tools for text-to-speech (TTS) or STT accommodations to support these learners.

Comprehension is another of the three guidelines (CAST, 2018). Students developing comprehension skills need teachers to plan a variety of ways to activate or supply background knowledge, highlight patterns, critical features, big ideas, and relationships; guiding information processing and visualization; and maximizing transfer and generalization. Search Engines are used frequently by all learners and provide a starting point for our study of multiple means of representing on the internet.

Universal Search Engines

For the purpose of this research, a *universal* search engine includes those most widely used by the population (like Google). Most people are familiar with the function of a search engine, even if the exact term for the search tool is unknown. Search engines are “special sites on the Web that are designed to help people find information stored on other sites” (Franklin, n.d., para. 2). They work using various algorithms, and in general, search engines provide search

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results based on important words, keep an index of the words they find and where they find them, and allow users to look for words or combinations of words in a particular index (Franklin, n.d.).

Even educators unfamiliar with UDL terminology have probably seen its principles in action with internet use. For example, Google, Yahoo, and Safari, among others, provide access to tools like microphones (in the search bar), which enable STT capabilities for students or internet users unable to access the internet with a keyboard. In addition, the artificial intelligence (AI) features of many search engines, referred to as Autocomplete (Sullivan, 2011) or Google Suggest (available since 2008), anticipate the spelling of search terms supporting developing spellers or those looking for information that is difficult to spell. As soon as a search begins, possible topics appear so the user can select from options before finishing the search inquiry (Figure 1).

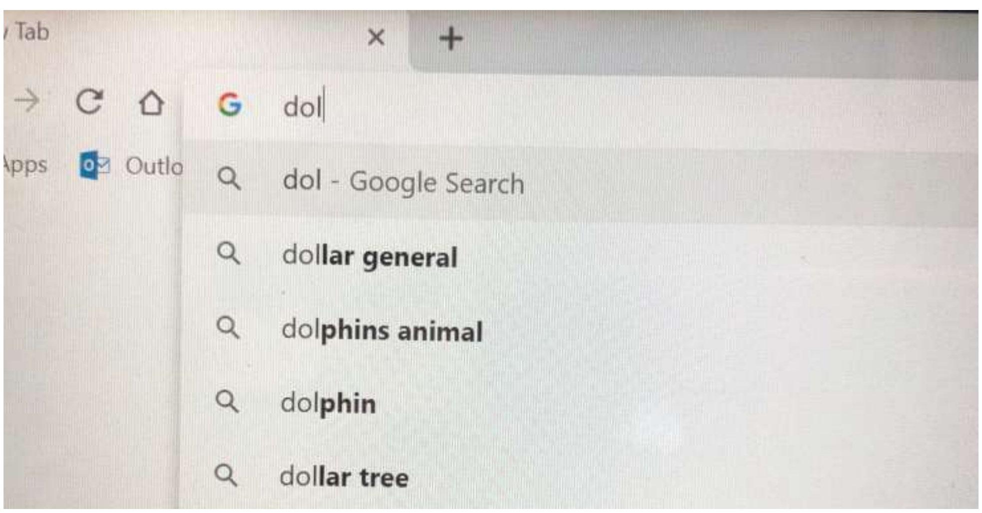

Figure 1. Google Suggest or Autocomplete

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Internet browsers and search engines also allow users to change language settings in order to conduct searches using a preferred language. This type of accessibility alleviates language barriers for our English Language Learners (ELLs) and emergent multilingual students (Figure 2).

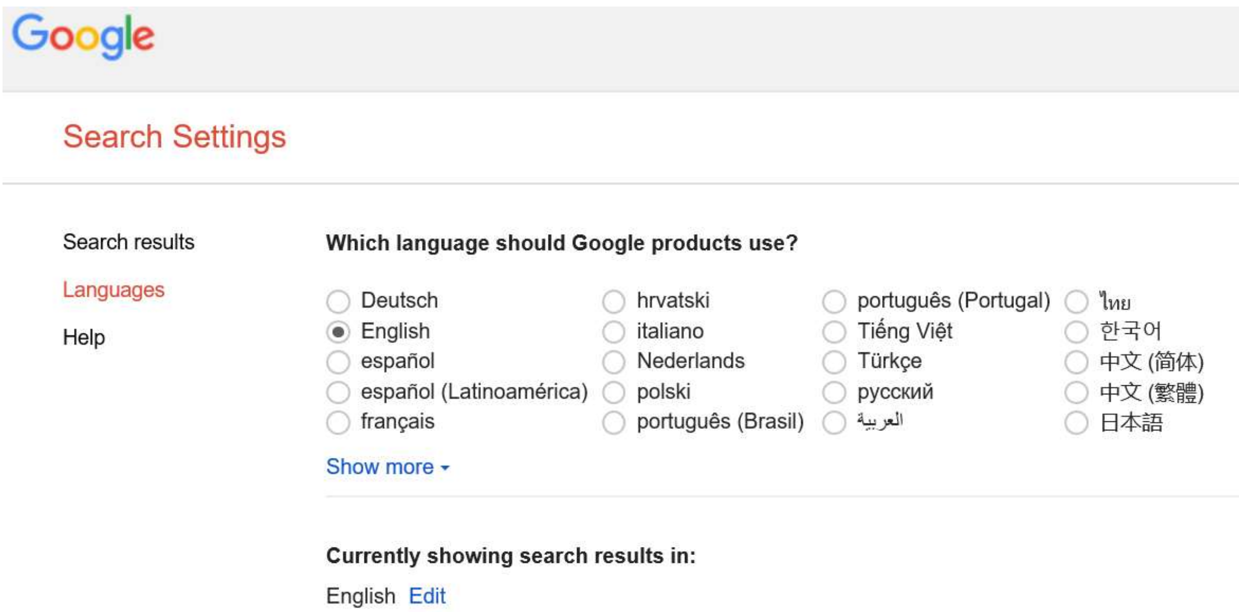

Figure 2. Language Affordances

In addition to the spelling, STT, and language features, some search engines offer setting adjustments and customization for users. Google settings include: languages, turn on SafeSearch, hide private results, advanced search (with even more options), search activity, your data in search, and search help. A Google Advanced Search offers additional ways to narrow a search, including but not limited to website domain (.edu, .com, etc.), file type (Adobe Acrobat, Microsoft Powerpoint, Shockwave Flash, and more), and usage rights (free to use or share, free to use, share or modify, and more). Other internet features include tools to adjust the font type and size. The options are incredibly broad when it comes to differentiated instruction for all

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learners. Table 1 presents an alignment of internet features and UDL guidelines for Multiple Means of Representation.

Table 1: *Multiple Means of Representing*

UDL Guidelines	**UDL Teaching Strategy Checkpoints**	**Available features on internet searches**
Provide options for perception	• Offer customized display of information • Offer alternatives for auditory information • Offer alternatives for visual information	• ✓ • ✓ • ✓
Provide options for Language and Symbols	• Clarify vocabulary and symbols • Clarify syntax and structure • Provide support for decoding of text or symbols • Promote understanding across languages • Illustrate through multiple media	• X • X • ✓ • ✓ • ✓
Provide options for comprehension	• Activate or supply prior knowledge • Highlight patterns, critical features, big ideas, relationships • Guide information processing, visualization, and manipulation • Maximize transfer and generalization	• ✓ • X • X • X

CAST (2018). Adapted from Universal Design for Learning Guidelines version 2.2. Retrieved from http://udlguidelines.cast.org

Search engines designed to engage young learners typically offer bright-colored interfaces and child-friendly user formats that are deemed safe with reduced distractions. Unfortunately, the child-friendly search engines that many teachers use for safety reasons and limited search results may not provide the same design features that the universal websites provide (Table 2). In other words, the standard search engine may best provide greater support and affordances for learner needs.

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Table 2. *Search Engines for Children*

Search Engine	Website Address	Description
Kiddle	Kiddle.com	Provides a safe visual search engine for kids.
Kidtopia	https://www.kidtopia.info/	Provides only websites recommended by teachers, librarians, and library and educational consortia.
DuckDuckGo	https://duckduckgo.com/?t=hp	Provides a search venue with no tracking, no advertising, and no targeting
KidRex	https://www.alarms.org/kidrex/	Provides "a fun and safe search for kids, by kids! KidRex searches emphasize kid-related webpages from across the entire web and are powered by Google Custom Search™ and use Google SafeSearch™ technology."
SafeSearchKids	https://www.safesearchkids.com/	Provides a filtered search result, powered by Google
KidzSearch (used Kidzsearch as its search engine)	https://www.kidzsearch.com/	Provides a "family friendly" search
DibDabDoo (use Safari to search)	https://www.dibdabdoo.com/	Child safe filtered internet search that uses Google Custom Search™
Kid's Search	https://kidssearch.com/	Provides a safe search engine with no ads.
WackySafe	https://wackysafe.com	Provides screened, kid-related webpages from across the web, powered by Google Custom Search™ and use Google SafeSearch™ technology

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As seen in the descriptions provided on the search engine websites (Table 2), most search engines advertise safety and filtered searches. We wondered if these built-in safe searches not only provide filters from harm, but also limited the number of search results so students would have fewer sites to sift through. In addition, we wondered if these search engines offer the same design features, and hence affordances, that standard search engines provide.

Method

In our previous analysis of children's websites (Vasinda & Pilgrim, 2019), we learned that children's websites do not always reflect what we refer to as the "Web in the Wild" (p. 97). At first glance, websites designed for children may appear similar to websites for the general population. There are menu bars, search boxes, and sometimes *liking* features, but content is often vetted to the extreme. For example, children's sites are often closed platforms, or *walled gardens*, in which searches stay within the service provider's site. In children's sites, there are often few hyperlinks, and, if there are hyperlinks, they connect to information within the service provider's site, in contrast to open platforms in which users have access to the World Wide Web. While this may be a good option for the youngest learners, it does not provide novice users with authentic skills needed to navigate the Wild Wide Web.

The purpose of this research was to analyze search engines designed for children to see what types of user support in terms of UDL's guidelines for multiple means of representation were available and if they were the same as those for universal search engines. This feature analysis, conducted in the summer of 2019, entails a systematic study of nine search engines designed for children. The research question for this study is: *How do adaptive affordances of*

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search engines designed for children differ from adaptive affordances of universal search engines?

Data Collection and Analysis

We first conducted a general search for children's search engines in the summer of 2019, using the keywords "children's search engines." We examined the lists of suggestions offered by various websites, including educatorstechnology.com and makeuseof.com. We were seeking sites designed specifically to be search engines. We checked out each search engine—in some cases, the search engines were no longer available. For example, Yahoo kids and other search engines powered by Yahoo were unavailable. GoGooligans appeared to be available but was not functioning properly; therefore, it was omitted from the list. In addition, we vetted suggested search engines to ensure they enabled children to conduct authentic searches on the internet. We omitted any results that resulted in a walled garden, meaning the site was a closed site so that a search stayed within the website pages (Technopedia, n.d.; Vasinda & Pilgrim, 2019), and these are often subscription sites in which a membership or site license must be purchased. For example, Fact Monster was suggested as a children's search engine by Educator's Technology (https://www.educatorstechnology.com), but Fact Monster only enables web searches within the Fact Monster site instead of the internet beyond Fact Monster's "walls." Our search for children's websites resulted in a total of nine free search engines for children (Table 2). DuckDuckGo seemed to be for a general audience, but we included it because it consistently appeared in searches for children's search engines, and its name has a child-like quality with a play on words from a children's recess game Duck, Duck, Goose.

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In order to systematically investigate children's search engines, we analyzed universal search engines to determine accommodating features for online searching. The resulting checklist includes both features and distractions found on universal websites when conducting internet searches. For example, menu options such as language choices and interpretive spelling are common features on Google. Additionally, potential distractions such as ads and social media icons (Pinterest, Facebook, Twitter, etc.) are included, as well. The domain (.com, org, etc.) of each search engine was also examined. Adaptive search engine features were examined to evaluate alignment with UDL Guidelines (Table 3). STT capabilities on search engines reflected UDL's guideline related to perception, so this became a data point for the researchers. An identifiable checkpoint for *Language and Symbols* was online language translation, so language options also became a data point for the researchers. Autocomplete became a checkpoint for comprehension, as researchers noted the ease of finding keywords when Autocomplete appears during the search. This checkpoint for *Comprehension* is easily identifiable, so the researchers agreed to use it as a data point. Other data points overlapped as multiple means of representing. Images within menu options, for instance, is a feature that may assist a variety of learners.

In this qualitative study, data sources included children's search engines, which were analyzed to determine the existence of affordances of children's search engines and how they may or may not differ from universal search engines. Researchers used the key word *dolphins* to initiate a search on each search engine for children. The researchers systematically examined the home page of each search engine, looking for features that enabled STT, language preference, autocomplete, etc. In addition to the checklist, researchers kept notes, which included special search engine features.

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Table 3*: Search Engines Designed for Children*

Search Engine	**# of results**	**Ads (Y/N)**	**Social Media**	**Domain**	**Menu Options (Y/N)**	**Speech -to- Text**	**Auto-complete**	**Language Options**
Kiddle	446,000,000	Y	N	.co	Y	N	N	N
Kidtopia	407,000,000	Y	Y	(.info)	Y	N	N	N
DuckDuckGo	N	Y	Y	.com	Y	N	Y	Y
KidRex	251,000,000	Y	N	.org	N	N	Y	N
SafeSearchKids	233,000,000	Y	N	.com	Y	Y	Y	N
KidzSearch	233,000,000	Y	Y	.com	Y	*	Y	N
DibDabDoo	420,000,000	Y	N	.com	Y	N	N	N
Kid's Search	249,000,000	N	N	.com	Y	N	N	Y
WackySafe	226,000,000	Y	N	.com	Y	Y	N	Y

Following the search on the children's search engines, we completed the same search for *dolphins* on four search engines for the general population: Google, Safari, Bing, and Yahoo (Table 4). We learned through our search that Yahoo is powered by BING.

Table 4*: Universal Search Engines*

Search Engine	**# of results**	**Ads (Y/N)**	**Social Media**	**Domain**	**Menu Options (Y/N)**	**Speech -to- Text**	**Auto-complete**	**Language Options**

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Google	410,000,000	Y	N	.com	Y	Y	Y	Y
Yahoo	29,800,000	Y	Y	.com	Y	N	Y	N
Safari	N/A	Y	Y	.com	Y	*	Y	Y
Bing	29,800,000	Y	Y	.com	Y	N	Y	Y

*Present through the keyboard

In this qualitative study, a deductive approach was taken during data analysis in that the researchers started with pre-existing principles of UDL, specifically the guidelines for multiple means of representation: perception, language and symbols, and comprehension. Data were collected to examine certain aspects of search engines, and data were analyzed to determine the existence of affordances of children's search engines and how they may or may not differ from universal search engines.

Findings

As we examined features and functions of children's search engines, we found differences reflective of audience age level and engagement, as one might expect. Search engine differences are important to report, as they relate to differences in how internet users perceive and comprehend information. We present our findings using the guidelines for multiple means of representation found in Table 1, perception, language and symbols, and comprehension, as categories. In addition, a recurring theme related to *safety* will be discussed as a finding.

Perception

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The UDL teaching strategies for the perception guideline include offering customized display of information, providing alternatives for auditory information, and providing alternatives for visual information. Three accommodations that support perception are Zoom, STT, and TTS functions. These affordances were found in some, but not all, children's and universal search engines.

Display of information. Display of information includes a variety of ways to visually represent text features. For example, when text size can be increased (Zoom) or a different font can be used, it can be beneficial to internet users with visual issues. The internet in general already provides this capability. Color and its use for information or emphasis is reflective of *perception.* Researchers noted some children's search engines provided color options for users. For example, KidzSearch included an adaptive feature where background themes could be set, and children can select a dark background for the search engine. The use of color in this manner uses contrast as a way to support uses with visual impairments. Color was evident throughout all of the children's search engines and used somewhat in universal search engines.

Display of information also includes the layout of visual or other elements affecting the perception of viewers. The layout of children's search engines was similar to that of universal search engines. Although many children's websites, like National Geographic, include large buttons that can be pressed on a screen by small hands, search engines, for the most part, resembled the linear display of textual information. All of the children's search engines we examined were bright, colorful, and used images appealing to children. KidRex even appeared to be designed by kids (Figure 3).

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Figure 3. KidRex interface

Another important text feature related to perception and the *display of information* was the menu. Menus often provide options that narrow searches or provide navigational support. In addition to menu "topics," menus often contain drag-down boxes that further narrow a search. The only children's search engine lacking a menu was KidRex. Most search engine menus provided unique menu options for the user. Kiddle's menu, for example, included Web images, Kimages, news, videos, and Kpedia. Kidtopia had many menu options (Figure 4), including a text-based menu at the top as well as subject-based buttons for users that use images for non-readers. Icons located below the menu bar are centrally located, allowing access with a click of a button to social media sites. We were surprised at the number of social media links included on Kidtopia, seen as smaller icons above the search bar.

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Figure 4. Kidtopia

Alternatives for auditory and visual information. Auditory and visual accommodations were offered in both children's and universal search engines. Perception for users with auditory and visual impairments were offered through the accessibility of STT and TTS features. They provide ways to improve viewers' perceptions, and understanding of information, on the site. As previously mentioned, the only universal search engine to offer STT and TTS capabilities for searching was Google.

In order to investigate perception on children's search engines, we specifically examined STT options during our *dolphin* search. Out of the nine children's websites reviewed, SafeSearchKids, Kidzsearch, and WackySafe included STT capabilities. The first two of these search engines are powered by Kidzsearch. WackySafe is powered by Google Safe Search. We didn't find Zoom or TTS capabilities on any of the children's search engines.

Language and Symbols

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The CAST checkpoints for the language and symbols guideline include clarification for vocabulary/symbols, clarification of syntax/structure, support for decoding of text/symbols, and illustration through multiple media. The typical affordances for this guideline are language translation features, TTS, and images/visuals such as the menu bar. These features were available for use more often in universal search engines than in children's search engines.

Clarification for Vocabulary, Symbols, Syntax and Structure. CAST (2018) recommends several strategies for vocabulary, symbol instruction, syntax, and structure. In terms of online support, children's search engines addressed vocabulary through the use of teaser texts. Teaser texts embed "support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations)." Teaser texts are explained in more detail later, as we determined they aligned with *comprehension* as well.

The most basic function of any search engine is to identify items, or websites, in a database that corresponds to keywords, specific vocabulary, submitted by the user. As we *searched* search engines, we noted the web address, or URL (Uniform Resource Locator). A URL creates a symbol to communication various bits of information to users by stating this information through a specific syntax and structure. A URL serves as a readable address representing a numerical code, or Internet Protocol (IP) address, for the location of resources on the internet, or in this case, the location of the search engine. Understanding the URL format provides insight into information about a website's content, author, etc. For example, https://literacy.example.com/games (a fictitious web address) would be interpreted in the format of protocol://domain.extension/other_information. The protocol, https (**h**yper**t**ext **t**ransfer

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protocol **s**ecure), indicates the site is secure. Next, the domain (IP address) includes the hostname indicating "literacy" is the network location. The last part of the URL is the extension (top-level domain). Theoretically (inconsistently), the extension identifies the source of the content such as country codes and categories (Table 5). The final section of the URL includes other information (this example indicates games), thus completing the unique web address for the resource found using keywords (November, 2008).

The domain differences were significantly different between children's and universal search engines. As seen in Table 4, all universal search engines had a .com domain, which means commercial or business. Search engines designed for children included a variety of the domain codes listed in Table 5. The domain differences may not mean much, other than teachers often advise students to avoid .com websites and use .edu, .gov, and .org for more reliable information. Yet, of interest, was Kiddle.co, which according to Kiddle the ".co" stands for "children only." Currently, there are several known meanings for the domain code, .co, beyond Kiddle's definition such as a new commercial or business domain code since .com is not available for that business and commercial business any longer and countries use it to identify their country (i.e., .co.cn means China). However, the approved definition by the Internet Assigned Numbers Authority for the .co code is for the country of Columbia (i.e., co.co) (Retrieved from https://www.iana.org/domains/root/db/co.html). So, extensions can be inconsistent in their meaning, but generally, the meanings for .edu, .gov and .org sites are recognized accurately and consistently.

Table 5

Internet Extension Codes and Initial Meanings

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Extension Code	**Initial Source of Content**
.com	Commercial or Business
.edu	Education, usually higher education
.gov	Government
.net	Networking Services (such as email / phone)
.org	Non-profit organizations
.co	Children Only/ Country/ Columbia (country)
.info	Information

Support for decoding of text/symbols. Support for decoding of text/symbols includes TTS capabilities, which is an overlap between the Perception and Language & Symbols checkpoints. Both of these checkpoints offer online tools, which can reduce the cognitive load associated with decoding. An additional way to support the decoding of text and symbols would be translation tools for second language learners. Seventy-five percent of the four universal search engines offer translation features, which are beneficial to a variety of learners and internet users. In children's search engines, only 33% of the nine search engines were found to provide language translation options. The prevalence of ads on children's search engines creates possible distractions to decoding on 88% of the search engines researched. The possibility of being distracted is even more of an issue on universal search engines, since ads were on 100% of the search engines we reviewed.

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Universal search engines provide additional language and symbol tools available to support a variety of users' needs for access in the options available on the webpage for each search engine. One such tool automatically offers intuitive suggestions for search terms after an entry is incorrectly typed and submitted by prompting a question in red, "Did you mean:…" followed by a possible correctly-spelled entry given in italics. The consistent exposure to text and symbols will provide assistance in decoding.

Illustration through multiple media. Providing multiple sources to represent the same information is a tool offered on universal search engines. Charts, animations, photographs, and videos are just a few of the ways one source of information could be illustrated in multiple manners than just by text. Our example, *dolphins*, provided these multiple sources of information when searched: video games, images, videos, a definition, and species information. The same affordances were not found on children's search engines.

Comprehension

The CAST checkpoints for the comprehension guideline include activation of prior knowledge, highlighted patterns, features, big ideas, relationships, guided information processing/visualization, and maximized transfer/generalization. Teasers are the main accommodation seen on both children's and universal search engines. However, universal search engines have additional comprehension tools to support the differing needs of users.

Activation of prior knowledge. An affordance of children's search engines were the visuals, or "teasers." We may not have determined what this feature was called had it not been for labels given to "missing" placeholders (Figure 5). Of the children's search engines analyzed, Kiddle, Kidtopica, SafeSearchKids (KidzSearch), DibDabDo, and Kid's Search included teasers.

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The visual feature, seen in Figure 5, provided additional focus on images, which children are typically drawn to during searches. Teasers seen during searches on children's search engines were large and provided scaffolding for young readers for prior knowledge or to provide a hook to entice them to learn more. After investigating if this feature is designated as a teaser in universal search engines, we found that it is still called a "teaser." Teasers on universal search engines are not only image-related, but also text-related, product-related, and more.

Figure 5. Teaser Placeholder

Highlighted patterns, features, big ideas, relationships. Processing information that is not text-related is an important option for users with special needs trying to use search engines. Explicit cues highlighted on a search engine assist users in attending to features that are more effective for their search instead of being distracted by irrelevant links. Universal search engines use patterns and relationships as part of the algorithm to predict word completion, or autocomplete. Autocomplete is an accessible tool for users struggling with comprehension of information. Surprisingly, children's search engines did not offer autocomplete as an affordance for users. It seems as if this might be an important addition to children's search engines since it would assist students struggling to figure out the most effective keyword or entry to find information online.

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Guided information processing/visualization and maximized transfer/generalization. Metacognitive strategies such as links and teasers guide users to process information. Most internet users are able to process information in a sequential manner without prompting, but some users need the suggestive links and teasers to visualize possibilities. Both children's and universal search engines used teasers to guide users towards finding the information they needed based on their entry into the search engine. Universal search engines use links offering prior knowledge or new knowledge and use teasers also to make search engines more accessible to all users. Yet, accessibility is only effective if, after processing information, users are able to generalize what was learned and apply it to a new situation.

Safety

We found many safety functions available on children's search engines that are unique in their efforts to protect young internet users. For example, Kiddle is a kid-safe visual search engine with "safe sites and pages written specifically for kids" (para 1). All Kiddle search results are handpicked and checked by Kiddle editors for content and safety. The first three results of a Kiddle search are safe, trusted sites that are not written specifically for kids, but have content written in a simple way, easy for kids to understand. The fourth to the seventh results are safe, famous sites that are written for adults, providing expert content, but are harder for kids to understand while still filtered by Google Safe Search. Finally, Kiddle search results after that are either handpicked and checked by Kiddle editors or filtered by Google Safe Search, returning kid-oriented results without any explicit content. Kiddle also provides big thumbnails and visual cues to make scanning easier and large Arial font to provide better readability. Additionally, Kiddle does not collect personally-identifiable information and deletes its log every 24 hours.

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In analyzing all of the other children's search engines, each claimed to provide a safe search option. Yet, the same can be said for the universal search engines analyzed for this study. Safe searches are a matter of using the settings in the web browser, which enable a safe search, prevent pop-up blockers, and more.

Key Differences between Children's and Universal Search Engines

Overall, one of the biggest differences between universal search engines and children's search engines is that universal search engines offered 50-100% of the criteria reviewed for this research. Children's search engines only ranged from 25-88% for the same criteria. Translation options were offered 75% of the time on the universal search engines reviewed but only 25% of the time in the children's search engines researched.

Menu options, autocomplete spellings, and ads were the criteria available most often on all of the children's search engines in this study. Similarly, menu options, ads, and domains were the criteria most often found on universal search engines. The criteria found least often on both children's and universal search engines were STT options, language translations, and social media links. Table 6 provides an illustration of similarities and differences for both types of search engines.

Differences between children's search engines and universal search engines were found to be significant only in search engine appearance, features, functions, safety, comprehension guidelines like autocorrect availability, and social media presence. Otherwise, children's search engines were similar to universal search engines for ads, domain codes, menu options, perception guidelines like STT, and language & symbol guidelines like online translations options. Unless

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you are teaching ELLs, it would be beneficial to use universal search engines in order to use the perception and language guideline features only available on these search engines.

Table 6: *Multiple Means of Representing: Search Engines*

Guideline	**Checkpoints**	**Children's Search Engine**	**Universal Search Engine**
Perception	• Customized display of information • Alternatives for auditory information • Alternatives for visual information	• Customized settings (Font size & style, contrast, color, etc.) • STT • TTS	• Customized settings (Font size & style, contrast, color, etc.) • Captions • TTS tools • Uses emoticons, images, & symbols to represent words
Language and Symbols	• Clarification for vocabulary/symbols • Clarification of syntax/structure • Support for decoding of text/symbols • Illustration through multiple media	• Online Language Translation (DuckDuckGo) • Images/visuals	• Online Language Translations on Google, Yahoo, and Bing • Images/visuals • Grammar and spelling accommodations • Virtual Assistants (Alexa, Siri, etc.) • Key vocabulary defined • Links to multiple forms of representation (charts, animation, photographs, etc.)
Comprehension	• Activation of prior knowledge • Highlighted patterns, features, big ideas,	• Teasers- next to search results to scaffold information	• Autocomplete • Links provided to relevant information which

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	relationships • Guided information processing/visualization • Maximized transfer/generalization	processing	might be prior knowledge • Teasers--scaffolds information processing

Implications and Conclusion

By design, the internet accommodates for learning differences through various ways of accessing information, such as textual, video, and audio modes. The comprehensive content and multimodal features are available to anyone seeking information. Additionally, we propose that the affordances of search engine options provide more than a scaffold for learners; they provide equitable access. We suggest that teachers consider the principles of UDL to leverage the accommodating search engine options for equitable access to internet information. These multiple options for access are always available, unlike the temporary scaffolds of assistance typically offered to vulnerable learners working towards fluency of a particular skill or strategy. The internet provides access for all with equity options and convenience features, and therefore, without overt notice of an adaptive technology scaffold.

What does this mean for teachers? Providing authentic experiences with online information is important (Dwyer, 2015). Overall, we recommend many opportunities for students to use the internet to locate and evaluate information. Search engines like WackySafe and KidRex serve as effective tools for authentic searches. Our findings indicate that children's search engines do not include the same affordances for learners as universal search engines. This limitation is an excellent reason for teachers to make sure children are able to navigate both universal and child-friendly search engines safely and effectively. Ultimately, it does not benefit

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children to only use children's search engines to locate information if they do not mimic the complexities of web-navigation. Teachers need to consider the use of accommodating search engines like Google and Safari, showing children how to use internet features in the setting options that enable access for all learners. As educators, we have a responsibility to keep our young readers safe, and we also have a responsibility to equip them to handle the discoveries and distractions of reading on the Wild Wide Web (Vasinda & Pilgrim, 2019). Learning to research online needs the same careful and explicit teaching we use for teaching research skills with paper texts. In other words, teachers need to use and model authentic searches and show students how to safely and critically examine Web content.

The Every Student Succeeds Act (ESSA) (2015) encourages states to adopt technology that aligns with UDL. The internet, the world's largest repository for locating information (Leu, Forzani, Timbrell, & Maykel, 2015), and the search engines that provide internet access are designed to support ESSA and UDL intentions. The internet *will* be accessed by children, so with careful lesson design and modeling, teachers can harness the affordances of the internet to make learning accessible for all learners.

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A critical analysis of technology's impact on teacher's views of literacy learning and teaching: A continuum of understandings

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Abstract

The purpose of this study was to investigate three middle school English teachers' understandings of literacy and technology. In particular, how do they view literacy and technology learning and teaching, and how do they use (or not use) technology to enact their views of literacy in their classrooms. This narrative inquiry qualitative study consisted of three open-ended interviews, written literacy narratives, and multiple classroom observations with each participant as well as the collection of various teacher documents, such as lesson plans, presentation notes, rubrics, and student handouts. Narrative methods were used in the data analysis. Findings were organized across a continuum of literacy understandings from traditional understandings to new conceptions of literacy. Discussion and implications point to the need for an expanded definition of literacy with teachers that addresses the complexity of multiliteracies. There is also a need for extending pedagogical repertoires of teachers to recognize TPACK as a beginning to multiliteracies.

Keywords: Multiliteracies, Technology, TPACK

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Introduction

Technology integration is commonplace in today's school contexts as more and more schools are moving to 1:1 implementation and online learning platforms. This presents unique challenges for different content areas, particularly literacy, as teachers and administrators sometimes do not know whether to focus on literacy, technology, or the interplay between the two. As technology is increasingly integrated, literacy is often left out of the discussion when considering how new technologies impact teaching and learning. This is especially problematic when literacy teachers possess traditional conceptions of literacy, and the affordances of technology do not necessarily support what they think they should be teaching and students should be learning.

What is missing in conversations and discussions is showing how technology can align with curricular goals and not using technology for technology's sake. Staples, Pugach & Himes (2005) noted, "The initial discussion of technology makes sense only insofar as it is directly related to the curriculum and is not focused on the acquisition of technology resources – either hardware or software" (p. 302). These discussions of curricular goals help address the relationship between technology and literacy content while aligning with standards, goals, means, and outcomes (Hew & Brush, 2007). Technology, then, is more of a curricular tool and not something that is to replace textbooks, other print-based texts, reading, and writing. It is important to move beyond simply focusing on technology and literacy, and instead expand both understandings and applications of literacy to literacies or multiliteracies, as espoused by New London Group (1996), who view literacy as continuous, new, supplemental, and enhancing or modifying established literacy teaching and learning rather than replacing traditional practices

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(Rowsell, Kosnik & Beck, 2008) and relate specifically to the types of literacies students interact with on a daily basis.

While studies have found that literacy teachers believe technology should be integrated into curriculum and instruction (McGrail, 2006; Hutchison & Reinking 2011; Ruday, Conradi, Heny, Lovette, 2013), much still needs to be learned about teachers' beliefs and knowledge of the best ways to integrate technology into the curriculum (McGrail, 2006; Ruday et. al, 2013). In particular, researchers need to turn to teachers to figure out how technology is impacting new conceptions of literacy and the conflicts inherent in this process (McGrail, 2006) as teachers are experimenting with connecting technology to student learning.

Literature Review

Multiliteracies

Multiliteracies recognizes both the increasing cultural and linguistic diversity in the new globalized society as well as the new text forms from multiple communicative technologies (New London Group, 1996). Literacy, then, "is more than reading, writing, speaking, listening, and viewing as traditionally defined. It is more useful to think of literacies, which are social practices that transcend individual modes of communication" (NCTE, 2018, n.p.). Therefore, educators have the responsibility to adjust their classroom practice to prepare students to become "active and successful participants in the 21st century globalized society" (NCTE, 2013, n.p.) by becoming proficient with different technological tools. This proficiency includes managing, analyzing, and synthesizing numerous types of continuous information.

Despite the recognition of technology's role in multiliteracies adoption, implementation into the classroom has often been met with resistance. This ranges from a skeptical viewpoint,

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requiring technology to prove its usefulness before integration, to a neutral viewpoint, where technology could be good but not necessarily connected to prime aspects of literacy, to a transformational view in which technology redefines literacy (Bruce, 1997; Labbo & Reinking, 1999; Swenson, Young, McGrail, Rozema & Whitin, 2006). Furthermore, Bruce (1997) argues that these views often place technology and literacy into two distinct realms that do not overlap or integrate. Labbo & Reinking (1999) and Walsh (2010) echo this sentiment in that educators have far too long thought of technology in terms of its technological aspects and less of what it means for different areas of literacy, particularly how technology transforms literacy practices. Thus, a different understanding of technology's role in literacy is needed, one that is more dynamic and multifaceted, where literacy is expressed through its technology rather than determined by it (Bruce, 1997) and "participation in *shaping* literacies becomes even more important than *acquiring* literacies" (Bloome & Enciso, 2006, p. 302, emphasis in original). Literacy and technology, then, act in conjunction with each other through socially constructed practices (Myers, 2006) that require new beliefs and new goals for the new digital multiliteracies.

If technology and literacy continually shape each other, and if educators are going to be truly equipped to prepare students to be active and productive participants in the evolving nature of literacy, not only do they need a multifaceted framework that reflects an integrated nature of knowledge, they also need an expanded view of literacy that includes multiple realities (Labbo & Reinking, 1999; Walsh, 2010). They need a pedagogy that ultimately supports the transformation of both practice and literacy understanding. The multiliteracies pedagogy provides a flexible and critical framework by which educators can prepare students.

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Multiliteracies pedagogy initially recognized the complex integration of four factors: situated practice, overt instruction, critical framing, and transformed practice (New London Group, 1996). Situated practice is “constituted by immersion in meaningful practices within a community of learners” (p. 33). This idea echoes the contextual nature of schools where technology will not work for every student in every situation or for every subject. Overt instruction allows teachers to scaffold learning activities to allow learners “to gain explicit information at times when it can most usefully organize and guide practice, building on and recruiting what the learner already knows and has accomplished” (p. 33). This similarly reflects the necessary technological knowledge teachers will need to pass along to students in topic-specific or subject-specific activities (Cox & Graham, 2009).

In critical framing, learners constructively critique what they have learned to extend and apply it to new and relevant innovations. Just as teachers need to be aware of the affordances and constraints of technology and what this means for student learning, teachers can also extend critical framing to ethical and social issues related to technological capabilities. The goal is ultimately transformed practice where “students can demonstrate how they can design and carry out, in a reflective manner, new practices embedded in their own goals and values” (New London Group, 1996, p. 35). Transformation takes place when students re-create knowledge and understanding suited to their own purposes:

> Teachers who are committed to a multiliteracies pedagogy offer their students ample opportunities to access, evaluate, search, sort, gather, and read information from a variety of multimedia and multimodal sources and invite students to collaborate in real and

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virtual spaces to produce and publish multimedia and multimodal texts for a variety of audiences and purposes (Borsheim, Merritt, & Reed, 2008, p. 87).

Building upon the New London Group's (1996) multiliteracies pedagogy, Cope and Kalantzis (2009) reimagined the pedagogy as knowledge processes and pedagogical acts to help extend literacy teaching and learning. Students and learners are at the center of these knowledge processes and pedagogical acts as traditional notions of literacy (reading and writing) are included and subsequently woven together with out-of-school literacies, with learners being active agents in the process. There is no map to follow; rather this type of pedagogy allows for alternate starting points for learning, forms of engagement, divergent learning orientations, and different modalities in meaning making (Cope & Kalantzis, 2009).

Technological pedagogical and content knowledge

To use technology effectively as indicated in the previous examples, teachers must possess specific knowledge about technology and how it can be used effectively in different content areas and instructional practices. Technological pedagogical and content knowledge (TPACK) (Mishra & Koehler, 2006; Koehler & Mishra, 2009) is built off Shulman's (1986) idea of pedagogical content knowledge, which integrates pedagogy and content. With the advancement of technology's role in education, a new understanding is needed that reflects how technology has changed or has the capacity to change classrooms. Teachers must learn the tools and also the techniques and skills needed to meaningfully and purposefully use technology to support learning. Technology is not static, which requires evolving thinking and knowledge. Quality teaching includes technology, pedagogy, and content and does not isolate them from

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each other. The TPACK framework can especially be utilized in situations where new technologies are constantly being introduced.

Currently, technology is not seen as transformative but rather as an aid or extension tool, and much of the lack of change in practice is dependent on the content area. Technology also has its own affordances and constraints and deciphering among these can be difficult, especially as teachers and teacher educators contemplate how, when, why, and to what extent to integrate technology into classrooms (Koehler & Mishra (2009). TPACK, then, helps clear up the messiness of meaningful technological integration into the classroom by giving teachers a clear and concise focus in their classrooms.

TPACK is flexible and does not prescribe a certain approach in its development, as "there is no single technological solution that will function equally well for every teacher, every course, or every pedagogical approach" (Harris, Mishra & Koehler, 2009). In addition, technology for technology's sake is not the main focus. A "content-neutral emphasis on generic software tools assumes that knowing a technology automatically leads to good teaching with technology" (Mishra & Koehler, 2006, p. 1031). With this in mind, "*integration efforts should be creatively designed or structured for specific subject matter ideas in specific classroom contexts"* (Koehler & Mishra, 2009, p. 62, emphasis in original). TPACK can be used across content areas according to specific goals, means, and outcomes.

TPACK is more focused on technology and how the teacher uses it to reach instructional goals, but is less concerned with the social and contextual nature of technology (Jacobs, 2013). The focus for this study includes elements of TPACK but is mainly focused on the broader picture of multiliteracies that "acknowledge the productive power of individuals as they engage

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in multimodal texts regardless of the technology required for that engagement" (p. 102). Multiliteracies also includes teachers' knowledge of the interplay between literacy and technology and how their practice supports learning within the larger multiliterate world.

Methodology

The teachers in this study possess unique backgrounds and lived experiences which contribute to their complex knowledge of literacy, technology, and teaching practice. In order to characterize "the phenomena of human experience and its study" (Connelly & Clandinin, 1990, p. 2) as well as "make visible the puzzles of the mind – framing, evidence, stances, theories, and questions" (Schaafsma & Vinz, 2011, p. 8), narrative inquiry was used as a means to access teacher knowledge to answer the following research questions:

1. How do practicing English teachers view technology and literacy?
2. How do practicing teachers use (and not use) technology to support their understanding and enactment of literacy in their classrooms?

This study used purposive sampling to focus on a school, College Prep Academy (all names are pseudonyms) that has transitioned to a 1:1 technological environment where every high school student had a laptop and every middle school student had an iPad. College Prep Academy is a 6^{th} – 12^{th} grade private religious school in a suburban Western location of the United States. At the time of the study, the student body was approximately 1,300 students with 600 in the middle school and 700 in the high school. The student body is primarily Caucasian from a mid to upper socioeconomic status. College Prep Academy has integrated technology into all subject areas and implemented extensive professional development with its teachers to be

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prepared to use technology in the classroom. The context of the school and the participants may not necessarily be typical of other private or public high schools. Although this is a unique school setting, this study may provide rich insights into other schools that experienced the same phenomena with literacy and technology and are struggling to make sense of how to meaningfully and purposefully adjust to the 21st century and its expectations for literacy education.

This study used homogenous sampling (Huberman & Miles, 2002) to identify practicing middle school English teachers who have used or not used technology to support their understanding of literacy in their classrooms and teaching practice. The homogenous sampling allowed for the topics of literacy and technology to be focused on exclusively and studied in-depth. The practicing teacher participants for the study were middle school English teachers who have undergone similar professional development, have had similar interactions with teachers and students in regards to the technology, and teach towards the same objectives and curriculum in regards to the implementation of technology in the classroom. The study focused on three middle school English teachers. At the time of the study, Maggie was in her 27th year of teaching, all of which have been at College Prep Academy. Maggie holds a master's degree in English education and taught three sections of the 7th grade advanced English classes. Lindsay graduated in 2005 and has spent her entire teaching career at College Prep Academy. She has taught mainly 7th and 8th grade English, both advanced and regular. Lindsay recently completed a master's degree in psychology with an emphasis in child and adolescent development. Rick was in his sixth year of teaching, all of them at College Prep Academy. He taught three sections of advanced 8th grade English, one section of regular 8th grade English, a middle school journalism

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class, and a middle school speech class. Rick has a degree in middle level/secondary education with an English Language Arts field endorsement. He was currently half way through earning his master's in curriculum and instruction with an emphasis on technology.

Data from the participants consisted of teacher literacy narratives, three open-ended interviews (Seidman, 2006), observations, and the collection of curriculum materials. The first interview focused on life history and past experiences in order to place the participants' experiences in context. The second interview focused on concrete details of participants' present lived experiences and occurred after three observations of each teacher's classroom. Finally, the third interview occurred towards the end of the school year in order to allow the participants to reflect on the meaning of the experience (Seidman, 2006). The third interview served as a member check and validation of the initial analysis of the data in order to clarify and solidify each teacher's knowledge of literacy and technology.

Detailed field notes of curriculum presented, teacher interactions with students, the classroom layout and design, the teacher's instruction, and other features of normal classroom practice were collected during classroom observations. Any teacher materials and curriculum used in the observed lessons were collected from each teacher. These materials included lesson plans, unit plans, student handouts, instructional examples and content, lecture notes and/or multimedia presentations.

The interviews, classroom observations, teacher literacy narratives, and teacher-created curricular materials served as multiple data points for analysis. Data was reduced into manageable and meaningful segments (Corban & Strauss, 2008, Creswell, 2013) by initially analyzing the data focusing on technology and literacy and technology and literacy instruction

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and practice. These topics were framed through the narrative inquiry space of interaction, continuity, and situation (Clandinin & Connelly, 2000). Analyzing data through the narrative inquiry space helped delineate among the temporal nature of stories and experiences, the need for balance between personal and social factors, and the influence of setting and context on experiences.

Findings

When considering Lindsay, Maggie, and Rick's literacy understandings in light of the research questions, the findings can be organized across a continuum. On one end, there are traditional understandings of literacy and technology and their role in classroom instruction. In the middle are more emerging and progressive understandings of literacy and technology where traditional ideas are still present but new understandings have developed. Finally, on the other end are new conceptualizations of literacy and technology and their role in the classroom. Lindsay can be categorized in the traditional understandings end of the continuum, Maggie can be classified in emerging understandings, and Rick can be categorized in new conceptualizations end of the continuum.

Traditional conceptions

Key to Lindsay's understanding of literacy is the concept of communication focusing specifically on reading and writing: "What do books communicate to their readers? How do people communicate in different ways via writing?" Lindsay sees literacy being connected "through stories and written communication" as a way to "bring feelings of self-worth and

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belonging." She also recognizes that communication has many different purposes for both her and her students:

> You can't communicate in a professional way with your boss if you don't know how. The way I communicate with my friends is different from the way I communicate with my students. They all have value, but it's going to be different… If I am writing a short story or a narrative, it's going to be different than if I am writing a paper for my master's class. I just think knowing when to do that and when to separate into those categories is so important and crucial for kids for that communication.

For Lindsay, literacy will always be closely associated with communication, reading, and writing.

Lindsay holds a fairly traditional view of the interplay between technology for both learning and teaching. Lindsay primarily sees students interacting with their computers and there is "very minimal interaction and communication with your teacher, and I feel like that's starting to clash and I don't think I'm going to be okay with that." Lindsay wants her students to use technology to "learn something and not just produce something….but from what I'm hearing technology is supposed to be and what I am seeing they are using. technology for, that's not the same."

Lindsay described technology's impact upon student learning as "conveniences": "I like that they can type up their essays and I like that they have research and things at their fingertips that they can go to." She thinks technology helps her students if they get "stuck" when they are writing as they can "click on and find some different words…and it's handy." Lindsay does recognize, though, that students are better able to research any topic, find examples, and then

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utilize the technology for better presentations: "When the kids do presentations, they put these things together with the technology. The things they can do are amazing because of all the different [technological capabilities]." When her students find their information, organize it, and put it into some kind of presentation, "the visual, the auditory, and the written compounded together is going to [help them] remember more." Despite this burgeoning understanding of how technology may positively impact student learning, Lindsay does not hold value in using technology in her teaching.

When questioned about technology and literacy in her teaching, Lindsay admitted that she stumbled with answering the questions because "I don't have a huge place for [technology] in my classroom right now. I just don't. I don't have a need for it because I've been teaching for nine years really without it." While technology doesn't have a large place in her classroom, Lindsay recognizes its importance in teaching, but she feels like "when you talk about pulling the teacher out and putting technology in, I just don't think that's a good step. I don't think that's a good way of looking at it." Therefore, she is mainly left with questions surrounding how technology can be used for teaching until she sees "what [technology] can do for literacy." She doesn't want to lose the content or have her lessons "watered down because I am just trying to put technology into play."

Lindsay feels so strongly about her ideas that she senses a personal clash between technology and education and literacy. She does not want teachers to be replaced by technology and when it comes specifically to reading and writing, she is not comfortable if writing "becomes something that [students] can just create or illustrate without ever placing a word on a page." Literacy will always be closely associated with communication, reading, and writing, and putting

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some sort of technological device into the hands of her students does not "convey the importance of learning to read and write. Until my students can head off to college and never have to write another essay again, I will not ease up on certain standards in my classroom concerning literacy." Lindsay's traditional viewpoints of literacy and technology are evident in her teaching practice.

Lindsay spends a lot of time on traditional reading and writing devoid of technology where she "really just takes what [my students] are reading and writing and learning about it and then putting that on paper and analyzing. We do a lot of essays that way as well." Lindsay also spends a lot of time talking about the different types of writing and thinks her students learn mainly from "the feedback they get, the work they produce, and then what I'm telling them and how to either fix up or change the way they are communicating within their written work."

Lindsay uses technology in limited capacities. One area technology is used is in improving her lectures as she "makes them more interactive" so students are able to make stronger connections to the information Lindsay presents. For example, as students began work on research papers, Lindsay provided minilessons about how to look for good online sources to get past Wikipedia, and to slow down and analyze the sites they would be using. Discussions centered around website publishing, credential checking, and the differences between analyzing and proving in writing. Lindsay also created a presentation on movie trailers in preparation for having her students create movie trailers over their class novel, *The Giver.* After teaching minilessons on the purpose of a movie trailer, plot structure, scene development and constructing a storyboard, Lindsay set her students free to create their trailers. She thinks the project is "kind of fun and allowed them to work together," but isn't sure if the project was "directly related to literacy, necessarily." She recognizes that "my students like it, but other than that, I don't know.

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I guess I just don't see a huge lack in my teaching or my classroom without having or knowing it." Lindsay uses technology in ways that support traditional reading and writing and in limited roles such as information gathering, presenting information, and word processing.

Emerging conceptions

Maggie's understanding of literacy specifically points to an evolution that includes reading, writing, speaking, listening, as well as basic thinking. Maggie's definition and understanding "as with most things, has changed and evolved over time." Maggie's definition originally adhered to the classical notion of "simply the ability to read and to write." Through her college and early teaching experiences, Maggie broadened this definition to include "thoughts to be examined, ingested, interpreted, argued over, understood, and written about." This broad definition of literacy "begins with the basic block of comprehension, and without that foundation, nothing more can get built." Therefore, Maggie's understanding of literacy is multilayered, with a strong foundation as the starting point.

Maggie's understanding of literacy continues to change "as technology invade[d] every aspect of daily life, even my classroom." She is "concerned what we consider to be literate: tweets. Everything is getting smaller and shorter and faster and that's where the kids are. Why say it in 10 words that sound cool if I can just say it in three?" Maggie doesn't necessarily think this type of literacy is valuable in a classroom setting despite how technology has shaped what constitutes literacy in today's world. On the other hand, Maggie recognizes her students are much more visual than the ones she had 27 years ago and tries to tap into the way they learn "to become literate in other ways, " recognizing the importance of understanding how to read and understand images. Still, Maggie is reticent to change her understanding of literacy. She will not

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give up her books, “for to open the pages of a book, to read it and to interpret it and to write about it and to discuss it – that’s literacy.”

Maggie’s main focus when she thinks of technology and literacy learning is “finding valid ways to use technology where [my students] are actually learning…To me that’s the big part and we are getting there slow but sure.” For Maggie, valid is when the technology “reinforces learning…If it engages them but at the same time teaches them a skill that will be necessary for the future learning, I think that’s valid.” The difficulty with technology and literacy learning is Maggie thinks her students see technology as “a toy first. It’s not an educational tool… So they are Facebooking and they are trying to get on other websites. Absolutely disengaged.” Maggie thinks this disengagement prevents students from learning skills of “researching and thinking and then putting it together.” This research includes recognizing while the “Internet is a great place, how do we find valid places to do our research when there are perfectly good books in the library?” Although Maggie does struggle with valid learning opportunities with literacy and technology, she does not think her students are missing anything if she does not always use technology in the classroom. She thinks students will use technology regardless and learn from it anyway.

Maggie remains firm in her views on technology and literacy teaching, especially when dealing with particular aspects of literacy. She “hates” writing on the iPads:

> It doesn’t give them the freedom to take a pen and go… “I want that sentence to go up here. That’s dumb, I want to cross that out.” By the time they’ve tapped on it and gotten it there, “Oh darn, I didn’t mean to highlight the whole sentence, I just want that one

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> word. What was I going to do again?" I've watched them stand in front of me and try to take a word out and respell. It's so hard to edit on the iPad, and to me that is a frustration.

Maggie has tried to use the iPads for reading purposes, but she has run into roadblocks as "you can't highlight or underline PDF's of stories off the Internet." She thinks "a literate reader in my opinion is active," and therefore underlining, circling, taking notes, and asking questions in texts as they read. Even with apps that do allow such navigation, Maggie thinks "it takes time…and if you don't touch it just right or your highlighter is wrong, it comes out ugly so nobody uses it." Maggie continues to adhere to traditional views of writing because "they haven't shown me anything that is better than what I've been doing. If I am successful at teaching writing, and I have been successful doing it for 27 years, why would I change that?"

Maggie, though, recognizes that "technology is here to stay, so I take that as a challenge to make sure that when we use it, it is valuable and valid." Therefore, Maggie has experimented with a variety of technological programs to help her literacy teaching. She has tried apps on the iPad like iBooks to create student reading materials, a PDF annotating app to teach her students how to be active readers, and numerous versions of Shakespeare to help with translating and note taking. Maggie has found these experiments "frustrating" because they often take more time than expected or don't quite accomplish what Maggie wishes they would.

Maggie has held on to her traditional views of literacy learning and teaching because she has yet to find how technology can do anything better than how she currently teaches and how her students learn. However, Maggie attributes these views to wanting to take the time to use technology for valid reasons, which cannot happen overnight. Therefore, rather than outright rejection of technology in literacy teaching and learning, Maggie is slowly integrating

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technology into her classroom where she feels it will enhance her students' learning and they will find value in using it to increase their understandings of literacy.

New conceptions

Rick recognizes his past experiences as being firmly grounded in reading and writing, but now his focus has turned to how to make meaning from a variety of sources and mediums. When thinking about his early understandings of literacy, Rick feels "for the most part my education has dealt mostly with people who thought literacy consisted of reading a text and answering questions or writing an essay." Today, Rick thinks literacy means "the ability to take information, interpret and understand it, in order to make new meaning [and] information out of it." Meaning can be found in "different types of media and…the literacy that goes with it: text literacy, technology literacy, visual literacy, audio literacy, video literacy, etc." These different types of literacy have impacted Rick's understanding of literacy as

> We are always going to need to know how to read and write, but we also need to know how do we incorporate these different medias and create something to not only show our understanding, but it gives understanding to others and maybe is a thinking point for someone else to go off of.

For example, Rick believes it is important to understand how to make meaning from a picture and to recognize all the different feelings and emotions inherent in one image. Similarly, the creation of a podcast that incorporates media, music, and voice to create a new form of communication is a way to take " information from different sources and understand it and digest it and make new meaning."

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Therefore, Rick has started to think of literacy having old goals and new goals. For example, old goals include reading a book, understanding it, and writing about it. New goals would be to take the same book, read it, understand it, write about it, "but communicate it to others. Show that you are literate by creating something new to demonstrate [your understanding]." Rick feels it is important for him as a teacher and for his students to be able to access all the different literacies and make meaning from them in order to be successful for the future.

Rick has rethought his views on student learning when considering what his students may pay attention to in his classroom, especially related to the technology. For example, when learning about Shakespeare, Rick's students may learn more from a virtual fieldtrip of the Globe Theater rather than just talking about it in class:

> It was a cartoon kind of thing, but it walks you through and you hear from different characters and there are a lot of images. Students can see that even though it's a drawing of what the Globe would have looked like, they can see it and think, "Okay, now maybe I can have a better understanding of that [idea]."

Additionally, Rick uses these ideas when incorporating research into his classroom. He has his students make meaning from traditional books, Internet websites, podcasts, pictures, and videos.

This idea of enhancing literacy learning through technology has been evident for Rick as his students "kind of surprise me" with the learning they are able to demonstrate. Oftentimes his students extend their learning beyond just answering questions for class "because they are finding these different resources from different websites that I had given them, and the information they are presenting to me is more than just answering the question." Rick views this

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type of learning important for his students' future job prospects as "a lot of jobs are going to incorporate using that technology to take that writing and take that research and create something new." In order to prepare his students for this type of future where literacy and technology meaningfully interact, Rick's views on technology and literacy learning have changed to use technology "transformationally" where it aids in literacy and helps his student gain new understanding.

Rick enacts his understanding of literacy as meaning making in his teaching practice. His students engage in the meaning making process by creating different projects, and Rick uses technology to support reading and writing. Admittedly, Rick says before his new understanding of literacy was shaped by his master's degree, literacy "maybe would be some lecture and then read and discuss and then take a quiz or a test." While Rick still feels there is a place for reading and discussing, he now spends much of his instruction and teaching practice finding meaningful ways to integrate technology for students to make new meaning from what they are learning. For example, while reading *Animal Farm,* Rick first started with a video on the Russian revolution and Stalin for character and conflict comparison as well as background for the book. Rather than a final essay over the novel, Rick's students had many video project options for their final assessment. These options included making a propaganda film from the perspective of the animals, a newscast explaining how people in town might feel about the farm, a talk show with characters from the book, or a podcast that included music and pictures and talking, also dealing with characterization. The purpose was to look more in-depth at the characterization and conflict and as a way to cover ideas that students may not have learned from the book. In projects like this, Rick readily admits his students often go beyond what is required and do a "good job of

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passing along new information and more information than I asked for…and it's relevant information."

Rick has also incorporated technology to support literacy learning by changing lessons from previous years. When discussing the characters in *Much Ado About Nothing,* last year, Rick spent a class period telling his students about every single character by asking "if you were going to cast a movie, who would you pick for these characters and why. I think that was okay, but I don't think that was the most valuable." This year, Rick had his students first start by researching the different characters on Spark Notes, and then using a word processing tool to have them create a family tree "showing how all the different characters are related to one another and show those connections and physically draw connections." Rick had trouble grading this assignment for he didn't know how the assignment was going to turn out or what exactly he was looking for, but he thought "it was just as effective or more effective than me lecturing for 45 minutes about the different characters."

Rick has sought ways to change his teaching practice to break out of the traditional methods of reading and writing by integrating different technology projects to support not only multiple literacies but also meaning making. These projects are primarily student-centered in nature and Rick thinks they are more valuable to his students' learning than simply reading a book, taking a quiz, and writing an essay.

Discussion and Implications

With the exception of Rick, the difficulty inherent in Lindsay's and Maggie's understanding of literacy is that, over time, literacy in their classrooms has become stagnant,

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creating almost a vacuum where traditional academic literacies of reading and writing become the sole focus of teaching and learning.

The first step for Lindsay and Maggie and a reminder for Rick is to recognize that literacy is always in motion (Cole & Pullen, 2010). To continue thinking of literacy in terms of just reading and writing is problematic (Jewitt, 2002). Rather, literacy forms and is formed by shifts of culture, capital, and emergent technologies (Luke, 2004). The complexity of literacy teaching and learning requires constantly evolving knowledge surrounding literacy. A more expansive view of literacy calls for English teachers – and in this case Lindsay and Maggie – to constantly redefine what it means to be literate (Cervetti, Damico, & Pearson, 2006), in order to respond to their students' responsibilities in the rapidly changing world.

The teachers at College Prep Academy need more formal knowledge or knowledge-for-practice (Cochran-Smith & Lytle, 1999) to expand their definitions of literacy and to find ways to use students' out-of-school literacies to support those within the school and institutional setting. The goal is not to find one method, but to have a flexible repertoire in response to different students (Luke, 2004) as well creating a more multiliterate view of curriculum (Boche, 2014). A multiliteracies perspective as well as the knowledge processes inherent in this perspective will help these teachers break free from the stagnant definitions they currently hold. Additionally, understanding that "responsive digital instruction today must focus on the contexts of literacies that are used" (ILA, 2018, para. 10) will help Lindsay, Maggie, and Rick recognize that technology plays a role in this process and they must continue to incorporate it into their teaching practice.

Literacy first, then technology

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Recognizing that new technologies have changed the ways in which we make meaning and, as such, require new meaning-making strategies, Lindsay and Maggie must develop an understanding of the interplay between literacy and technology. The focus, however, is on literacy and multiliteracies and not technology (Hicks, 2006). Hicks (2006) argues that teachers should instead be focusing on how literacies are affected by all that technology enables. In fact, "multiliteracies are relevant to English classrooms because we – students perhaps more importantly than teachers – have the advanced ICTs that allow multiliteracies to happen" (Grabill & Hicks, 2005, p. 303). Therefore, teachers must have opportunities to "think critically about pedagogical concerns…and about the intellectual, social, cultural, political and economic impact of using [technology]" (Swenson et al, 2005, p. 219) when considering literacy's role in the classroom.

Multiliteracies also offers opportunity for agency. First, these new technologies and literacies allow users to co-construct their knowledge and understanding more than ever before (Cope & Kalantzis, 2010; Kimber & Wyatt-Smith, 2006). Teachers are no longer isolated individuals who are forced to come together once a week for collaboration. Instead, there exists more opportunities for co-authoring and tapping into stored knowledge to develop and shape learning experiences for students with digital learning and texts (Kimber & Wyatt-Smith, 2006). Thinking about literacy and technology in light of multiliteracies forces teachers to be proactive. Multiliteracies is constantly changing, and teachers can be designers and co-constructors of their own teaching and learning. Rather than waiting for technology to decide how literacy functions in the classroom, the teachers could instead shape how the technology promotes different types of literacy learning, dependent on their goals. For example, they should be instructing technology

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companies on how apps should work to support revising and editing in the writing process rather than rejecting technology altogether. In this regard, teachers are the key agents in their efforts to change what they would like to see in their classrooms (Young & Bush, 2004). An expanded definition of literacy and expanded views of literacy and technology will also greatly serve Lindsay, Maggie, and Rick as they consider enacting these views in their teaching practice.

TPACK as just the beginning

In the TPACK model, the goal is for teachers to gain technological pedagogical content knowledge (Mishra & Koehler, 2006; Koehler & Mishra 2009). Much of the attention in TPACK is on matching technology with curricular goals (Blanchard, 1994) and learning the different techniques and skills to meaningfully integrate technology. In the TPACK model, technology is not considered a static entity. Rather, teachers need proper techniques and skills to meaningfully integrate technology with both informal and formal knowledge. While recognizing the affordances and constraints of technological devices as geared towards content areas, Hicks (2006) contends the focus should be less on technology and more on what it means for students and teachers to be multiliterate. Hicks argues "we want the conversation to be about more than adaptation and use; we want it to be about sound teaching and critical literacy practices that incorporate technology" (Hicks, 2006, p. 47). With TPACK, the focus is on design and literacy first and technology second, as teachers need to consider why different technologies matter to English teaching, what it means to be a producer and consumer of traditional and digital texts, and how different literacies and technologies relate to the larger picture of literacy learning (Hicks, 2006; Swenson et al., 2006). Developing TPACK in teachers requires much more than creating a product with technology. Explicit connections between technology and literacy

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learning (Hutchison & Wang, 2012; Boling, 2008) are needed to move beyond just using technology in a basic way in English teaching and learning.

Much of the focus for the teachers in this study was on the technology. They were curious as to how iPads could help in their classrooms, what apps and programs other people were using to be successful, and how to use technology in valid and reliable ways. They were not sure if they were using the technology in the optimal way but as a substitution tool for pencil and paper. For example, Lindsay often had questions about what technology should look like for her curriculum. Was it supposed to be some sort of game that helped with vocabulary learning? Was it supposed to help her students understand how to organize information by providing a confusing paragraph where students would have to reorder the sentences to help it make sense? Was the technology supposed to aid in the writing process by providing a revolutionary way to revise and edit on the iPad without having to print out paper copies? Lindsay, Maggie, and Rick were all left wondering when the technological revolution would take hold and what that was supposed to look like in their teaching practice.

Connecting TPACK to literacy is a difficult concept that different researchers have linked to teacher learning in successful ways. For example, Rosaen & Terpstra (2012) created a New Literacies project that examined eight different literacies through a wiki with online activities and articles, videos and classroom examples, and written reflections. Similarly, Graham & Benson (2010) started with small projects, analyzing TV shows and creating non print-based activities, in order to foster awareness, critical thinking, and recognizing multiple modes to create meaning. These inquiry-based approaches to integrating technology in literacy practices (Hicks, 2013) can be flexible, collaborative, and allow teachers to think rhetorically about the

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issues of technology in teaching. Understanding the relationships between traditional and digital texts, while capitalizing on their unique potentials (Swenson et al., 2006), can create opportunities to increase learning, competence, and attitudes towards literacy and technology (Hutchison & Wang, 2012,). Besides the creation and design of texts, teachers also need to discuss the effects of participating in the design process (Miller, 2007) in order to gain a better understanding of how they themselves become more multiliterate (Hicks, 2006) and, in turn, help their students become more multiliterate as well.

Conclusion

This study has shown that as new technologies take hold in the literacy classroom, teachers will need to be equipped with new understandings of literacy as well as new methods to enact these understandings. Literacy education can no longer be limited to the traditional literacies of reading and writing. Instead, teachers will need to help students think of literacy differently and as permeating into all areas of their lives. The teachers in this study were very much into the replication process of teaching and learning: The students read a book, gained some new insight into what they read, and wrote essays or created presentations on what they learned. There is merit in these processes as they can help students develop close reading skills, develop academic writing skills, and develop their vocabulary and exposure to literature. The replication process, however, does not always allow for critical conversations or connecting literacy to students' out of school literacies.

Instead, to help students become more multiliterate into today's world, teachers will need to model multiliteracies and scaffold student learning to help make explicit connections between what students are learning in school to literacy acts they engage with outside of school on a

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regular basis. The teachers in this study provided glimmers of new thinking and instructional practices to support these ideas, but also presented missed opportunities to extend their own thinking and learning as well as their students. Literacy education can no longer let these opportunities pass by. Therefore, we must equip teachers with the necessary knowledge and skills to engage in this important intellectual work.

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Game-Based Literacies and Learning: Towards a Transactional Theoretical Perspective

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Abstract

Current research suggests digital games can positively affect learning by motivating students in ways that traditional learning may not. Some argue that games possess similar elements to other signifying systems, including reading and writing. Employing a design-based research framework and drawing connections between gameplay and literacy, we explored how games may benefit from the literacy field's transactional theory to interpret the ways gameplayers' efferent and aesthetic stances affect gameplay and learning. Results indicated that (a) students with efferent stances may be better suited to game-based learning; and (b) games must be purposefully designed to manage the cognitive load required by the content and navigation features. Future research should focus on more in-depth analyses of in-game performance and its relationship to learning outcomes as well as further explore how transactional theory can be used to understand students' approach to gameplay using a combination of aesthetic and efferent stances.

Keywords: Game-Based Learning; Literacy; Transactional Theory; Cognitive Load; Design-Based Research

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Game-Based Literacies and Learning: Towards a Transactional Theoretical Perspective

Today's students are involved in a variety of literacy practices as they increasingly engage in digital gameplay on computers, hand-held devices and mobile phones, both in and out of school (Noonoo, 2019). Gee (2003) explains there are various ways of reading and writing and, each way is rooted in "a lived and historically changing set of discursive practices" (p. 21). In many ways gameplay is similar. Buckingham and Burn (2007) argue that there are numerous features that games share with other signifying or representational systems, including reading and writing. Games are almost always multimodal texts, where different communicative modes are combined, such as sound and music, speech and writing, and still and moving images. Spires (2015) notes, "Just as literacy practices are contextualized in social situations and relationships, game players establish shared language and understandings within a game; in essence they gain fluency in a specialized language" (p. 126). This assertion was also illustrated through a recent discussion by Lasley (2017).

Gee (2003) asserts that, "When people learn to play video games, they are learning a new literacy" (p. 13). He adds that in addition to the traditional idea of reading and writing, literacy is also tied to semiotics and social practices. Whether one fully agrees with Gee's definition of literacy or not, it is hard to ignore that there is a growing recognition of the transformative potential of video and online game-based learning in education.

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As numerous scholars have observed, a diverse range of students are poised to take advantage of educational games (Gee, 2007; Gibson, Aldrich, & Prensky, 2007). Educators and researchers are continuing to explore ways to appropriate the best features of game-based learning and bring them into the classroom. Generally, the research literature is divided into studies that focus on learning and studies that examine effects on motivation and engagement.

The studies that focus on learning do so in a variety of ways. For example, some research has shown that games can help students learn content in various subjects, such as science (Lester, Spires, Nietfeld, Minogue, Mott, & Lobeni, 2014), math (Castellar, All, de Marez, & Van Looy, 2015; McLaren, Adams, Mayer, & Forlizzi, 2017; Ninaus, Kiili, McMullen, & Moeller, 2017), English (Yip & Kwan, 2006; Pruden, Kerkhoff, Spires, & Lester, 2017), and foreign language (Johnson, 2010). Studies have also shown that games improve specific skills, such as problem solving (Chuang & Chen, 2009; Kolovou & Heuvel-Panhuizen, 2010; Liu, Cheng, & Huang, 2011; Spires, Rowe, Mott, & Lester 2011; Ya-Ting, 2012) and knowledge acquisition (Brom, Preuss, & Klement, 2011; Chuang & Chen, 2009; Huizenga, Admiraal, Akkerman, & Dam, 2009; Manfra & Spires, 2013; Papastergiou, 2009).

Research on games has evolved to the point that researchers have conducted meta-analyses to demonstrate the impact on learning. Recent meta-analyses have shown that games have an overall significant, positive impact on learning (e.g. Zhonggen, 2019; Lamb, Annetta, Firestone, & Etopia, 2018; Backlund & Hendrix, 2013; Clark, Tanner-Smith, & Killingsworth, 2016; Merchant, Goetz, Cifuentes, Kenney-Kennicutt, & Davis,

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2014; Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013). The literature, however, is divided on the impact games may have on overall school-based academic achievement, which may be due to issues with measurement (Perrotta, Featherstone, Aston, & Houghton, 2013).

Many studies have also shown that games can improve students' engagement and motivation for learning (e.g., Papastergiou, 2009; McLaren et al., 2017; Sung, Hwang, Lin, & Hong, 2017; Sawyer, Smith, Rowe, Azevedo, and Lester, 2017). The meta-analysis conducted by Wouters et al. (2013), however, found that games did not differ from non-games with motivational outcomes. Nevertheless, Clark et al.'s (2016) more recent meta-analysis, which examined motivation along with other factors such as work ethic and intellectual openness as part of intrapersonal learning outcomes, found that games do support overall improvements in this area.

In recent years, there has been the emergence of theoretical and epistemological foundations for games (Gee, 2017; Aldrich, 2004; Prensky, 2006). As participants at the National Summit on Educational Games as far back as 2006 concluded, the key issue confronting the educational community is clearly articulating *why* and *how* games are effective. Although great strides have been made to meet this goal from 13 years ago, there are still not clear answers due to issues such as inconsistent measures of variables like learning, motivation, and academic achievement (Perrotta et al., 2013). Furthermore, researchers must strive to provide practical guidance for how and under what conditions games can be integrated into the classroom to maximize their learning potential. An essential question for educators is whether students can increase their school related

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content knowledge and academic achievement through a game experience (Perrotta et al., 2013).

The purpose of this article is twofold: First, we introduce the research and development process for CRYSTAL ISLAND, a narrative-centered learning environment, and propose this game as an exemplar that has the potential to affect school-based learning. Second, by drawing connections between gameplay and literacy, we explore how game research can benefit from theoretical perspectives from the literacy field, especially from transactional theory (Rosenblatt, 2004; McEneaney, 2003).

The Case of CRYSTAL ISLAND

CRYSTAL ISLAND is a narrative-centered learning environment that was created by Dr. James Lester, Director of the Center for Educational Informatics, and a multidisciplinary team at North Carolina State University (for a description of the multidisciplinary community, see Spires & Lester, 2016). Adopting Bruner's (1990, p. 35) assumption that "The system by which people organize their experience in, knowledge about, and transactions with the social world . . . is narrative rather than conceptual," CRYSTAL ISLAND designers embedded the science content within a strong narrative as a way to engage game players and help them better learn the content.

CRYSTAL ISLAND's science mystery was based on the NC Standard Course of Study for eighth-grade microbiology. Students work to uncover the identity and source of an infectious disease that plagues a research station. The story opens by introducing students to the island and members of the research team for which the protagonist's father serves as the lead scientist. Several of the team's members have fallen ill, and one of the team

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members accuses another of having poisoned the other researchers. Students must discover the outbreak's cause and source and either acquit or incriminate the accused team member.

Throughout the game, students explore the island and interact with other characters while generating hypotheses and collecting data to test their hypotheses. Students can pick up and manipulate objects, take notes, view posters, operate lab equipment, and talk with non-player characters to gather clues about the source of the disease. During the course of solving the mystery, students are minimally guided through a five-problem curriculum. The story and curriculum are interwoven throughout the student experience.

Theoretical Perspectives

The two theoretical underpinnings that guide this exploratory research are transactional theory (Rosenblatt, 1994; 2004) and cognitive load theory (Sweller, 2005). Both theories are discussed in conjunction with properties of game-based learning.

Gameplay and Transactional Theory

In addition to the discursive practices that are shared by both traditional and game-based literacies, it can be argued that both types of literacies can be explained by transactional theory (Rosenblatt, 1994; 2004). There are two core ideas related to transactional theory. The first core idea is that meaning is produced within a transaction between a reader and a text (Rosenblatt, 1978). For example, in contrast with more traditional models of reading, which typically "locate" meaning within the text and

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conceive of reading as the extraction of that meaning, transactional theory defines meaning as rooted in a reader's personal experience in reading, subject to personal reflection and self-awareness, and shaped by the reader's efforts to explain what is understood to others.

The second core idea is that the understanding a reader creates depends on stance, which refers to the orientation of the reader's attention—which may depend upon various factors, such as the type of text being read or purpose of the reader for engaging with the text, and may alter as the reader progresses through the text. Stance is defined as a continuum that moves from aesthetic to efferent points. Rosenblatt (2004) notes, "the efferent stance pays more attention to the cognitive, the referential, the factual, the analytic, the logical, the quantitative aspects of meaning" while "the aesthetic stance pays more attention to the sensuous, the affective, the emotive, the qualitative" (p. 1374). For example, when taking an aesthetic stance, readers might read for the pleasure they derive from the act of reading. According to Rosenblatt (1978), "in aesthetic reading, the reader's attention is centered directly on what he is living through during his relationship with that particular text" (p. 25). On the opposite end of the continuum is the efferent stance, in which a person reads to specifically learn more about the topic discussed in the book. As Rosenblatt (1978) states, with an efferent stance, "the reader's attention is primarily focused on what will remain as a residue after the reading — the information to be acquired, the logical solution to a problem, the actions to be carried out" (p. 23).

Historically, transactional theory assumes that the reader naturally takes a stance during reading (McEneaney, Li, Allen, & Guzniczak, 2009) or more likely, moves up and

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down a continuum from aesthetic to efferent while reading in order to accomplish a reading goal (Spires & Donley, 1998). However, McEneaney et al. (2009) found that when using expository hypertext, the researchers were able to influence readers' stances through reading prompts. They also found that aesthetic readers exhibited a higher understanding of the text. This finding was surprising, as the researchers anticipated that efferent readers would better understand nonliterary text, since previous research had shown that aesthetic readers better understand literary texts (Many, 1990; 1991).

There is a wealth of research and theory that demonstrates how digital environments affect the ways in which readers process information (e.g., Wolf, 2018; Leu, Kinzer, Coiro, & Cammack, 2004). However, using a transactional theoretical lens to interpret readers' processes is still under-explored. McEneaney et al. (2009) were among the first to explore transactional theory in digital environments, specifically with hypertext. The exploration of transactional theory within game-based learning environments is a natural progression since games are multimodal texts.

Just as good readers adopt a particular stance to accomplish their reading goals, game players may also utilize a stance, such as those in the efferent/aesthetic continuum, to "read" and play the game. However, which stance or combination of stances is more effective for gameplay or learning has yet to be demonstrated. This study is designed to take the first step in exploring players' stances and their relationship to gameplay and learning outcomes.

Gameplay and Cognitive Load Theory

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In designing CRYSTAL ISLAND, we considered Sweller's (2005) cognitive load theory, which holds that schemata are the structures that form a person's knowledge base. There are three sources of cognitive load: intrinsic, extraneous, and germane (Sweller, van Merrienboer, & Paas, 1998). The intrinsic cognitive load deals with the cognitive load required to learn the content of the subject matter being presented, which, in CRYSTAL ISLAND, is microbiology. The extraneous cognitive load refers to the unnecessary cognitive load required by the instructional design elements of the game. For example, if a game is poorly designed, a student may experience more cognitive demand when attempting to understand how to play the game. Ideally, game designers should work to keep the extraneous cognitive demand low or nonexistent and work to optimize the germane cognitive load, in which the game works to aid the player in processing and understanding the content more deeply.

To stimulate learners to use the appropriate cognitive processing, we kept in mind that it is the total cognitive load of the game that matters most; the game must be within learners' working memory limits. With a narrative-centered learning environment such as CRYSTAL ISLAND, the balance between narrative structures and content is tenuous. If the appropriate balance is not achieved, learners' working memory may be overloaded which may negatively impact learning (Kiili, 2004). As Kiili (2004) notes, "cognitive load should be optimized in games by cutting down irrelevant multimedia elements, applying modality effect, providing usable user interface and challenges that support knowledge construction" (p. 21-22).

Study 1

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This exploratory research investigated the effects of the CRYSTAL ISLAND environment on student science learning, interest, and reading stance (Rosenblatt, 1994) using a design-based research methodology (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). Design-based research was appropriate since the team was using student data to create new iterations of the game. We hypothesized that students who participated in the CRYSTAL ISLAND conditions would perform better both on science learning and a problem-solving task than students in a control condition.

Methods

Participants. A total of 151 eighth grade students participated in the study (males = 78). Approximately 55% of participants were European American, 26% were African American, 6% were Asian, 5% were Hispanic or Latino, and 8% identified as other. Participants' ages ranged from 12 to 15 ($M = 13.26$, $SD = 0.523$). The students completed the state-mandated standard course of study microbiology curriculum before receiving the instruments, interventions, and tests of this experiment.

Students were randomly assigned to one of three experimental conditions: CRYSTAL ISLAND Narrative ($n = 60$), CRYSTAL ISLAND Narrative-Light ($n = 55$), and Content Control ($n = 36$). Uneven numbers across conditions was due to missing data on either pre or post-test, as the two tests were conducted a week apart. The difference between the Narrative and Narrative-Light is that the Narrative condition had more storyline details included.

Materials and procedures. The materials and procedures as part of the methods include CRYSTAL ISLAND curricular development, CRYSTAL ISLAND environment

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development, and detailed procedures in order to conduct the research.

CRYSTAL ISLAND curricular development. CRYSTAL ISLAND was designed around five curricular goals. The first goal of the learning environment was to identify that the inhabitants of CRYSTAL ISLAND have fallen ill due to a pathogen. This required users to learn about what a pathogen is and is not. They also had to apply this information to the narrative story. The second curricular goal of CRYSTAL ISLAND required users to learn more about viral, bacterial, and fungal pathogens. Users had to learn about the microbiological structure of these pathogens individually, including the size, shape, and components, in order to complete this goal. The third curricular goal built upon the second by requiring users to integrate their knowledge about the microbiological structures in order to make comparisons across pathogens' size, shape, and components. The fourth curricular goal of CRYSTAL ISLAND required users to create and test hypotheses about what types of pathogen was causing the CRYSTAL ISLAND illness and its origin. In order to complete this goal, users had to learn about and apply the scientific method, while integrating their knowledge about pathogens. The fifth and final curricular goal was to learn about how one would treat and/or prevent various pathogenic illnesses. The development of the curriculum was aligned with the NC Standard Course of Study for eighth grade microbiology content.

CRYSTAL ISLAND environment development. Key features in the first iteration of the CRYSTAL ISLAND learning environment included:

1. Character interactions were fully text-based and menu-based.
2. Students could take notes, but not while simultaneously talking to a character,

reading a book or poster, or working with the factsheet.

3. Students answered a total of 26 True/False questions posed to them by characters at the end of conversations. They were given the chance to answer a question only once before moving on.
4. The narrative was largely linear. Students needed to complete one goal (talking to a character) before being permitted to proceed to the next. If spoken to, every character would prompt the student to go speak with the current goal's target character.

Procedures. Pre-intervention assessments for each participant were completed one week prior to the intervention. These materials consisted of a researcher-generated CRYSTAL ISLAND microbiology content test and demographic survey.

Participants in the two CRYSTAL ISLAND conditions (Narrative and Narrative-Light) were directed to examine CRYSTAL ISLAND instructional materials, which consisted of a description of the backstory, the task, and the characters. Participants also received a map of the island and a control sheet. Participants in the two conditions had 50 minutes to solve the mystery. During this time, students needed to accomplish various goals, including learning about pathogens; recording the symptoms of the sickened researchers; noting features of hypothesized diseases causing the CRYSTAL ISLAND illness; testing possible sources; and reporting the solution to the camp nurse to develop a treatment plan.

Content from the curriculum used to develop CRYSTAL ISLAND was translated into PowerPoint format to serve as a Content Control condition. Each slide covered a segment

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of the curriculum and was designed to replicate a classroom PowerPoint presentation. The presentation consisted of slides with the same verbiage and images that were included in the CRYSTAL ISLAND experience. The PowerPoint did not include the narrative and plot central to CRYSTAL ISLAND. Participants were instructed to go through the PowerPoint at their own paces. At two points during the PowerPoint students were prompted to take a quiz; the same quiz questions used in the CRYSTAL ISLAND quizzes were used in the PowerPoint.

After the designated amount of time had lapsed (50 minutes), all participants were instructed to move on to the post-intervention phase. All students completed assessments that included multiple-choice content questions and the Perceived Interest Questionnaire. The intervention procedures were implemented as intended. For the two CRYSTAL ISLAND conditions, not all students completed all elements of intervention by the end of the designated 50 minutes, while all students in the PowerPoint condition finished. Evaluation of the intervention was based on the intervention as delivered.

Measures

Research measures for the first study included multiple-choice content questions, the Perceived Interest Questionnaire (PIC), and think-aloud protocols (TAPs).

Multiple-choice content questions. The pre- and post-intervention content test consisted of 23 questions designed by an interdisciplinary team of researchers and curriculum specialists. Two eighth-grade science teachers critiqued the content test to establish content validity. Based on examination of parallel analysis, results from an exploratory factor analysis (promax oblique rotation), of the 23-item multiple choice

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items at post-test reduced to form five factors of questions: 1) 5 items focused on information concerning all pathogens in general, 2) 3 items about the size and shape of pathogens, 3) 5 items concerning illness or diseases caused by pathogens, 4) 7 items specifically about viruses, and 5) 3 items specifically about bacteria. Structure coefficients between factor and their corresponding questions ranged from .32 to .98 and correlations among factors ranged from .06 (illness and bacterial specific questions) to .25 (illness and all pathogen general questions). Internal consistency estimates between questions for within each factor were: general pathogen ($\alpha = .84$), size and shape ($\alpha = .81$), illness and disease ($\alpha = .73$), virus ($\alpha = .87$), and bacteria ($\alpha = .75$).

Perceived interest questionnaire (PIQ). The PIQ was adapted from measures used by Schraw (1997) to examine within-subject relationships with learning outcomes. The measure consists of ten Likert items measuring students' situational interest related to CRYSTAL ISLAND and Content Control interaction. To illustrate the scale, example items include the following: "I got absorbed with CRYSTAL ISLAND without trying to," and "CRYSTAL ISLAND really grabbed my attention." The PIQ for the Content Control condition was identical to the CRYSTAL ISLAND version except "The PowerPoint" was substituted for "CRYSTAL ISLAND." Internal consistency among the 10 items was high at $\alpha = .94$.

Think-aloud protocols. In order to understand more fully what aspects of the gameplay students were focusing on, we conducted think-aloud protocols (TAPs) with a small sample of 7 students (male = 4). Four participants were European American, 2 were African American, and 1 was Latino. We asked for teacher recommendations for students

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who would be able to articulate their game playing process.

Early work by Ericsson and Simon (1980) suggested that TAPs "interpreted with full understanding of the circumstances under which they were obtained, are a valuable and thoroughly reliable source of information about cognitive processes" (p. 247). Researchers have used TAPs to evaluate student engagement with multimedia or online environments across many academic disciplines (Coiro & Dobler, 2007; Damico & Baildon, 2007; Pressley & Afflerbach, 1995). During an individual 1-hour session, the researcher asked a student to think aloud while playing CRYSTAL ISLAND. If the student went three minutes without talking, the researcher prompted the student by saying, "Please, think aloud as you play the game" (Hilden & Pressley, 2011). The students' verbalizations were digitally recorded and transcribed verbatim. The transcriptions were analyzed in verbal units, which in this case were verbalized sentences, using Rosenblatt's (2004) transactional theory as a lens for analysis. Three of the seven student transcripts (42.8 % of the transcripts which included 44.8 % of the total verbal sentences) were randomly selected for coding in order for the researchers to establish inter-rater agreement, Cohen's Kappa = .914, $p < .001$. Specifically, two researchers independently coded sentences in one of three categories: (a) logistical, (b) aesthetic, or (c) efferent. A logistical response related to the student trying to figure out how to navigate the game (e.g., "I don't understand how to move to the Infirmary"). An aesthetic response focused more on emoting with the text (e.g., "I don't like this character because he seems sinister"). An efferent response focused on analyzing the factual content of the game (e.g., I think salmonella is causing people to get sick on the island"). In addition to the

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two transactional categories of aesthetic and efferent, the logistical category referred to the logistics of getting around within the game—and did not relate to an aesthetic or efferent stance.

Results

Science content learning across experimental conditions. A preliminary analysis was conducted to ensure that there were no differences among the condition's (Narrative, Narrative-Light, Content Control) pre-intervention science curriculum test scores. An analysis of variance (ANOVA) indicated that as would be anticipated due to random assignment, there were no significant differences among conditions, $F(2, 146) = 2.734$, $p = .068$, $\eta^2 = .036$.

To examine the effect of the intervention on students' science content learning, a RM-ANOVA was conducted with the within-subjects variables of occasion (pre- and post-intervention), multiple-choice question type (general pathogen, size and shape, illness and disease, virus, and bacteria question types) and the between-subjects factor of condition (Narrative, Narrative-Light, Control). Analysis indicated that there was a main effect for occasion, $F(1, 146) = 44.696$, $p < .001$, $\eta^2 = .234$, such that collapsed across condition, students experienced a significant gain in performance from the pre- to the post-test assessment. Students answered on average 1.776 ($SD = 3.3$) more questions correctly on the post-intervention test than on the pre-pre-intervention test. Moreover, there was a significant occasion by condition interaction, $F(2,146) = 9.905$, $p < .001$, $\eta^2 = .119$, indicating that learning gains differed by condition. As seen in Figure 1, the largest learning gains occurred in the Content Control condition ($M = 3.51$ items, $SD = 3.61$),

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followed by the Narrative-Light condition (*M* = 1.25, *SD* = 3.26), with the lowest learning gains occurring in the Narrative condition (*M* = 0.56, *SD* = 2.76). Bonferroni post-hoc comparisons revealed that there were significant learning gains for both the Content Control ($p < .001$) and Narrative-Light conditions ($p = .006$); however, the learning gains in the Narrative condition were non-significant. Post-hoc comparisons indicated that the learning gains for the Content Control were significantly greater than gains experienced by both the Narrative ($p < .001$) and Narrative-Light ($p = .004$) conditions' learning gains. Lastly, the results indicated that there was not a significant three-way interaction between occasion, question type, and condition, $F(8,288) = 1.32$, $p = .232$, $\eta^2 = .035$. Therefore, the relation between occasion and condition did not differ as a function of question type.

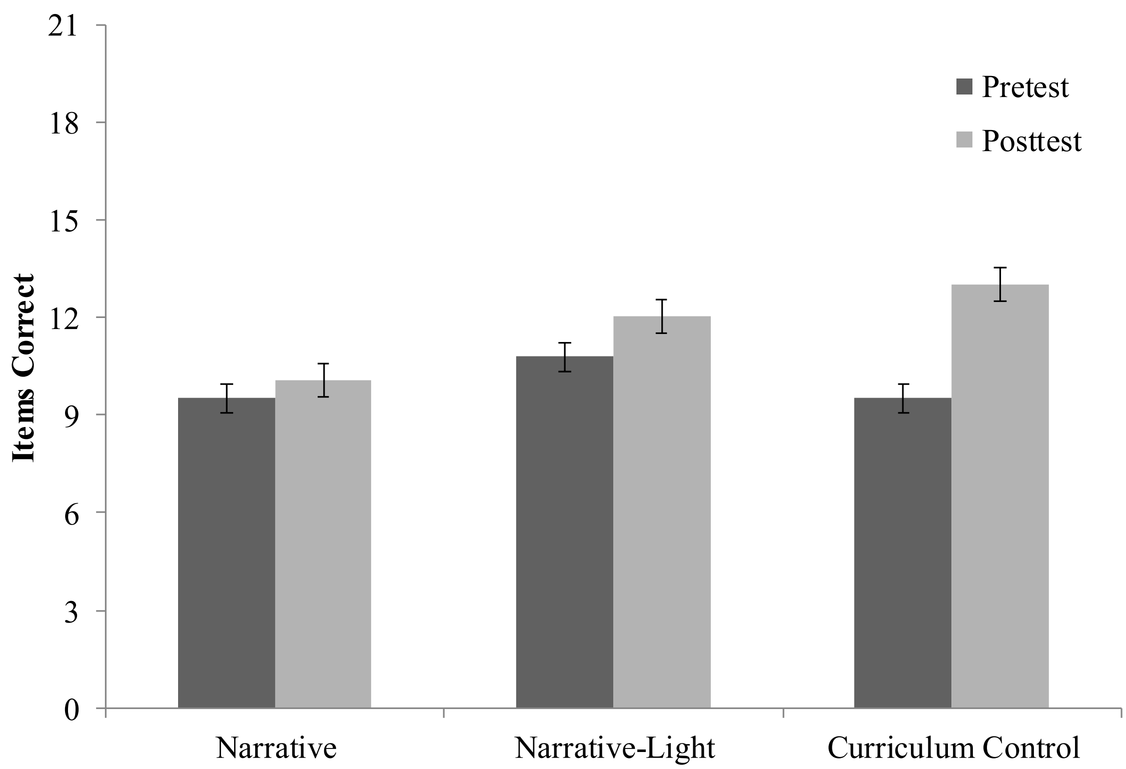

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Figure 1. Pretest and posttest means for microbiology contest test by experimental condition in Study 1. Standard errors represented in the figure by the error bars attached to each column.

Engagement ratings across experimental conditions. To examine if students reported differential levels of engagement across the experimental conditions, an analysis of variance was conducted (ANOVA) with the between-subjects variable of condition (Narrative, Narrative-Light, Control) and the dependent variable of PIQ score. Results indicated that there was a significant effect of condition, $F(2,146) = 3.328$, $p = .042$, $\eta^2 = .042$. Bonferroni post-hoc comparisons revealed that students in the Narrative-Light condition ($M = 3.53$, $SD = 0.92$) reported a significantly higher rating of engagement compared to their peers in the Content Control condition ($M = 3.02$, $SD = 0.97$), $p = .038$. Students in the Narrative condition did not report engagement ratings that were significantly different than their peers, *p*s > .443.

Think aloud protocols. The results showed that out of a total of 791 verbal units, 286 (36%) were deemed to be of a logistical nature, 319 (40%) were of an aesthetic nature, and 186 (23%) were of an efferent nature (see Table 1). Noting the relatively low percentage of efferent verbal units (23.51%) relative to logistical and aesthetic units (76.49%) and the variation in use of efferent units (range = 14.29% to 34.55%), we used these results to inform our next iteration of the game in hopes of scaffolding students' focus on the efferent or instructional elements of CRYSTAL ISLAND.

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Table 1

Study 1 Think Aloud Verbal Unit Distribution

Source	Logistical	Aesthetic	Efferent	Total Verbal Units
Student 1	84 (57.93%)	38 (26.21%)	23 (15.86%)	145
Student 2	34 (34.34%)	38 (38.38%)	27 (27.27%)	99
Student 3	26 (23.64%)	46 (41.82%)	38 (34.55%)	110
Student 4	91 (47.15%)	50 (25.91%)	52 (26.94%)	193
Student 5	9 (16.36%)	34 (61.82%)	12 (21.82%)	55
Student 6	30 (28.57%)	60 (57.14%)	15 (14.29%)	105
Student 7	12 (14.29%)	53 (63.10%)	19 (22.62%)	84
Total	286 (36.16%)	319 (40.33%)	186 (23.51%)	791

Discussion for Study 1

Our hypothesis that students participating in the CRYSTAL ISLAND conditions would perform better on a science content measure than students in the control condition was not supported. While students in all three conditions increased their science content knowledge, students who were exposed to the content in a direct fashion through a self-paced PowerPoint presentation scored higher than students who participated in the CRYSTAL ISLAND game. There are several factors that could contribute to these results. First, in our attempt to control for time on task, we did not provide enough time for all

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students to complete the game. This, of course, limited potential test performance for students in the CRYSTAL ISLAND conditions since all students were not exposed to the microbiology content. Second, the intelligent version of the software provided customized scaffolding for students as they progressed through the game; it is possible that the amount of scaffolding was not adequate to provide support for all students to successfully navigate the game in the allotted time. Third, while CRYSTAL ISLAND provides substantial motivational benefits with regard to self-efficacy, presence, and perception of control, it appears that student learning gains are less when compared to a PowerPoint control. It is possible that both the game actions and the narrative storyline could have provided extraneous cognitive load, serving only as a distraction from the science content to be learned.

Previous research has demonstrated the power of games to engage and motivate students as discussed earlier. Based on our results here, it appears that in order to facilitate significant learning gains, students must be given ample time to complete the game as well as customized scaffolding support. Since one unique aspect of a game is that students approach the environment and task idiosyncratically, it is important to capitalize on this phenomenon within the game experience. Based on our results, it appears that the narrative storyline served as a distraction and added extraneous cognitive load for students.

Based on the analysis of the TAP data, we made improvements to the logistics of the game and in the next iteration included instructional scaffolds that encouraged the students to focus on the science content and therefore a more factual, analytic, and

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therefore efferent stance. In essence, the scaffolds positioned the content more to the forefront of the game experience to optimize germane cognitive load, which we hypothesized would cause students to adopt an efferent stance more often. With these modifications in place, we conducted a second study to see what, if any, effects there would be on science learning as a result of playing the game. Specifically, we hypothesized that scaffolding that increased students' efferent stances while playing the game would help students focus more on the science content, which would be evident on measures of content knowledge.

Study 2

The purpose of the second study was to explore how transactional theory (Rosenblatt, 1978; McEneaney, 2006) might serve as an interpretive lens for narrative-centered game-based learning. Transactional theory was leveraged in the present study in several ways, with the second core idea—that a reader's understanding of a text depends on their stance—being the main focus of the investigation. First, transactional theory was used to inform the creation of content scaffolds within the game in order to provide a game or "text" that might evoke efferent responses. These content scaffolds were intended to perform in conjunction with the narrative aspects of the game in order to achieve an optimal cognitive load balance between efferent and aesthetic game-player stances. The effectiveness of the scaffolds was examined. Second, transactional theory was also used to explore if individual differences in stance predict effectiveness in gameplay as indicated by learning gains and completion of in-game goals. Complementing this goal, the relation between in-game performance (i.e., goal

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completed) and learning outcomes was also examined. Lastly, we explored if students' stances influenced how they interacted with the learning environment, which in turn influenced how much they learn (i.e., does in-game performance mediate the relation between stance and learning gains?).

Methods

Participants. A total of 100 eighth grade students participated in Study 2 (males = 51). Approximately 48% of participants were European American, 35% were African American, 12% were Hispanic or Latino, 2% were Asian, and 3% were of other races. Participants ranged in age from 12 to 15 (M = 13.38 SD = 0.51). The students had not completed the microbiology curriculum mandated by the state standard course of study before receiving the instruments, tests, and interventions of this experiment.

Participants were randomly assigned to one of three conditions: CRYSTAL ISLAND with the efferent content scaffolding (Scaffolding, n = 28), CRYSTAL ISLAND without efferent content scaffolding (Non-Scaffolding, n = 37), or Content Control (n = 35). A total of four sessions were held over two days. Students who did not complete all four sessions were excluded from the analysis, which resulted in uneven numbers across conditions. The Scaffolding condition was identical to the Non-Scaffolding condition except for in the Scaffolding condition the addition of prompts received via the game's personal digital assistant (PDA), which helped students address some perceived shortcoming in their microbiology knowledge, or otherwise aid them in solving the mystery. The selection of which prompt was presented to a student was based on a Bayesian student model. Prompts were presented every three minutes; however, students

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could also request prompts via the PDA.

Materials and procedures. Materials and procedures included ***CRYSTAL ISLAND*** curricular development, ***CRYSTAL ISLAND*** environment development, and detailed procedures in order to conduct Study 2.

CRYSTAL ISLAND curricular development. The curriculum was refined from Study 1. In particular, there was a reduced focus on fungi and parasites resulting in the removal of purposeful exposure to information on these two topics.

CRYSTAL ISLAND environment development. The CRYSTAL ISLAND environment was also refined from Study 1 in order to increase the effectiveness of the intervention. Changes included:

1. Multimodal Communication: Character interactions included voice-acted spoken dialog, which was lip-synced and included gesture, facial expression, and eye contact.
2. Narrative Minimization: The poisoning/character conflict elements of the storyline were removed. The conflict element was removed based on the Study 1 finding that the narrative element did not enhance students' science learning.
3. Learning Tool Enhancements: A communicator device (aka PDA), which was used to take and view notes, consult a microbiology field manual, take quiz questions, and request hints, was added. PDA afforded students the opportunity to take notes at any point in the game. Refinements were also made to the Study 1 fact sheet in order to enhance students' ability to draw conclusions to solve the science mystery. Specifically, the new diagnosis worksheet was organized into

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subcomponents (patient symptoms, laboratory test findings, estimates of predictive likelihood of particular causes, final solution) that highlighted what types of information would be necessary to know for solving the mystery.

4. In-game Assessment Refinement: Quiz questions were multiple-choice with four possible answers each instead of true/false.

Procedures. In the CRYSTAL ISLAND conditions (Scaffolding and Non-Scaffolding), students were first provided general information about the CRYSTAL ISLAND narrative and game controls during an introductory presentation by a researcher. Following the instructions, students completed the pre-intervention multiple-choice content questions. Students had 60 minutes to solve the CRYSTAL ISLAND mystery. Solving the mystery consisted of learning about pathogens, viruses, and bacteria; developing a list of the symptoms of the sick researchers; recording notes about diseases possibly afflicting team members; testing possible sources for the disease; and finally, reporting the disease, as well as its source, cause, and treatment, to the camp nurse. After the time had lapsed (increased from Study 1 to 60 minutes) or the participants had completed their interaction, students were instructed to continue to the post-intervention phase where students completed assessments that included multiple-choice content questions, two application-level constructed responses, a measure of stance, and the Perceived Interest Questionnaire.

As in Study 1, content from the curriculum used to develop CRYSTAL ISLAND was translated into a PowerPoint format to serve as the Content Control condition. Participants were instructed to go through the PowerPoint at their own paces. At two

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points during the PowerPoint, students were prompted to take a quiz; the same quiz questions that were used in the CRYSTAL ISLAND quizzes were used in the PowerPoint. Following the instructions on how to use the PowerPoint and quizzes, students completed the pre-intervention multiple-choice content questions. After the completion of the Content Control interaction, participants were instructed to move on to the post-intervention phase. As with the CRYSTAL ISLAND condition, students completed assessments that included multiple-choice content questions two application-level constructed responses, and the Perceived Interest Questionnaire.

The intervention procedures were implemented as intended. For the two CRYSTAL ISLAND conditions, not all students completed all elements of intervention by the end of the designated 60 minutes, while all students in the PowerPoint condition did. To account for variation in the degree to which students completed the CRYSTAL ISLAND intervention, information on in-game performance was collected in Study 2. Evaluation of the intervention was based on the intervention as delivered.

Measures

Research measures for the second study included multiple-choice content questions, application-level constructed responses, the Perceived Interest Questionnaire (PIC), measure of stance, and in-game performance.

Multiple-choice content questions. The pre- and post-intervention content test consisted of 16 questions designed by an interdisciplinary team of researchers and curriculum specialists. Two eighth-grade science teachers critiqued the content test to establish content validity. The assessment was a modification from the version given in

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Study 1. In particular, this test was reduced to 16 questions to reflect the reduction of content presented in the CRYSTAL ISLAND interaction. Questions were also reworded to result in 8 factual-level questions that were designed to be direct and literal in nature and 8 application-level questions that were designed to require an application of knowledge to a situation. Confirmatory Factor Analysis supported this 2-factor solution, χ^2 (103, N = 100) = 100.62, p = .548; *RMSEA* < 0.01, *CFI* = 1.00, *IFI* = 1.02. In addition, standardized path coefficients indicating the relation between factors and their corresponding questions ranged from .19 to .61, and all coefficients were significant at $p < .05$. Internal consistency estimates between literal questions and between application questions were high at α = .89 and .86, respectively.

Application-level constructed responses. Edling (1993) found that knowledge transfer is a skill that can be developed through active engagement with a contextualized learning environment. As CRYSTAL ISLAND provided students with a highly contextualized learning environment, we anticipated that the game would enable students to better apply the information learned in the game.

To test this prediction, two application-level constructed responses were developed. Students were asked to answer the following questions as best as they could: 1) Imagine that you have three microbes that are three different sizes. Please explain how you could identify each microbe if you know that one is a virus, one is a bacterium, and one is a fungus and 2) A scientist wonders if a new microbe she has found could cause illness in humans. She wants to be a good scientist and has come to you for advice. In this specific situation, develop a set of instructions to complete each step of the scientific method. The

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concepts need to solve the two questions were central learning goals to the CRYSTAL ISLAND and Content Control conditions.

Coding of the application-constructed responses consisted of a 0 to 2 scale. Response 1 was coded as 0 = no relevant information or wrong; 1 = organized by size or lists relevant distributing information; 2 = fully explains which type of pathogen is largest and which is smallest. Response 2 was coded as 0 = no relevant info or wrong; 1 = lists steps of scientific method; 2 = explains the steps for this particular problem. Two coders achieved reliability on a subset of the questions ($\kappa \geq .91$). One coder then coded all remaining responses, while the other coded 25% of the responses to verify final reliability. Reliability for Response 1was $\kappa = .83$ and reliability for Response 2 was $\kappa = .89$. The average of the two scores was used in subsequent analyses.

Perceived interest questionnaire (PIQ). The PIQ was identical to the measure used in Study 1.

Measure of stance. To measure stance, students in the two CRYSTAL ISLAND intervention conditions were presented with the open-ended prompt "Tell us what you recall from the game" order to assess the most salient concepts recalled from the game. Similar measures of stance have been done in previous research (McEneaney, et al., 2009). The main purpose was to assess a student's stance at the end of the game, or in other words, whether the student focused on and therefore recalled more of the content or efferent aspects of CRYSTAL ISLAND or the emotive or aesthetic—the narrative—aspects of CRYSTAL ISLAND. It was not presented to the Content Control condition since there was no narrative component.

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The measure of stance was coded on the following 0 to 3 scale, borrowing from McEneaney, et al.'s (2009) procedures: 0 = no relevant info; 1 = narrative or aesthetic focus; 2 = efferent focus; 3 = both aesthetic and efferent focuses. Two coders achieved reliability on a subset of the questions ($\kappa \geq .93$). One coder then coded all remaining questions, while the other coded 25% of the questions to verify final reliability of κ = 1.00. Due to small cell sizes associated with the 0 to 3 scale, the coding scheme was dichotomized to 0 = Non-Efferent focus (previous coded 0 and 1) and 1 = Efferent focus (previously coded 2 and 3).

In-game performance. While students interacted with the CRYSTAL ISLAND software, their progress was recorded in the game (i.e., student traces). The present study examined one aspect of these traces, Goals Completed. To complete CRYSTAL ISLAND, participants had to complete seven goals; however, not all students completed all the goals in the 60 minutes allotted. Therefore, Goals Completed could range from 0 to 7.

Results

Science learning across experimental conditions. Pre- and post-intervention multiple-choice content questions' descriptive statistics are provided in Table 2. Preliminary analyses were conducted to ensure that there were no differences among the conditions' (Scaffolding, Non-Scaffolding, Content Control) pre-intervention factual and application test scores. An analysis of variance (ANOVA) indicated that as would be anticipated due to random assignment, there were no significant differences among condition for factual and application questions, $F(2, 96) = 0.19$, $p = .831$ and $F(2, 96) = 0.51$, $p = .604$, respectively.

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Table 2

Study 2 Multiple-Choice Content Questions Descriptive Statistics

	Pretest		Posttest	
	Mean	SD	Mean	SD
Scaffolding (*n* =28)				
Factual Questions	3.11	1.13	4.64	1.81
Application Questions	3.50	1.23	3.75	1.62
Non-Scaffolding (*n* =37)				
Factual Questions	3.28	1.39	4.57	1.91
Application Questions	3.14	1.55	4.35	1.44
Content Control (*n* = 35)				
Factual Questions	3.14	1.06	4.37	2.22
Application Questions	3.31	1.43	4.23	2.26

To examine the effect of the intervention on student performance on factual-level multiple-choice questions, a RM-ANOVA was conducted with the within-subjects factor of occasion (pre- and post-intervention) and the between-subjects factor of condition (Scaffolding, Non-Scaffolding, Content Control). Analysis indicated that there was a main effect for occasion, $F(1, 96) = 42.79$, $p < .001$, $\eta^2 = .31$, such that collapsed across condition, students experienced a significant gain in performance from the pre- to the post-intervention assessment. Bonferroni post-hoc comparisons revealed that all conditions experienced significant learning gains, *p*s ≤ .001. Largest learning gains occurred in the Content Control condition ($M = 1.54$, $SD = 2.06$), followed by the Non-Scaffolding condition ($M = 1.33$ items, $SD = 2.06$), and the Scaffolding condition ($M = 1.23$, $SD = 2.09$). Additionally, there was not a significant occasion by condition

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interaction, $F(2, 96) = 0.18$, $p = .840$, indicating that learning gains did not differ by condition.

To examine the effect of the intervention on student performance on application-level multiple-choice questions, a RM-ANOVA was conducted again with the within-subjects factor of occasion (pre- and post-intervention) and the between-subjects factor of condition (Scaffolding, Non-Scaffolding, Content Control). Analysis indicated that there was a main effect for occasion, $F(1, 96) = 42.79$, $p < .001$, $\eta 2 = .31$, such that collapsed across condition, students experienced a significant gain in performance from the pre- to the post-intervention assessment. Bonferroni post-hoc comparisons revealed that the Non-Scaffolding ($M = 1.19$, $SD = 2.07$) and Scaffolding ($M = 0.91$, $SD = 1.45$) conditions experienced significant learning gains, ps $\leq .009$. However, the Content Control condition ($M = 0.25$, $SD = 1.95$) did not experience a significant gain ($p = .518$) even though the occasion by condition interaction was not significant, $F(2, 96) = 1.74$, $p = .182$.

Lastly, to examine the transfer effect of the intervention, an ANOVA was conducted to examine if there were condition differences in performance on the averaged performance on the two application-level constructed responses. Results indicated that there were no differences among the Scaffolding ($M = 0.76$, $SD = 0.71$), Non-Scaffolding ($M = 0.75$, $SD = 0.57$) and the Content Control ($M = 0.73$, $SD = 0.66$) conditions, $F(2, 97) = 0.02$, $p = .983$.

Engagement ratings across experimental conditions. To test if students reported differential levels of engagement across the experimental conditions, an analysis of

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variance was conducted (ANOVA) with the between-subjects variable of condition (Scaffolding, Non-Scaffolding, Content Control) and the dependent variable of PIQ score. Results indicated that there was not a significant effect of condition, $F(1, 95) = 1.16$, $p = .318$, such that engagement ratings for the Scaffolding ($M = 3.08$, $SD = 0.93$), Non-Scaffolding ($M = 3.37$, $SD = 0.88$), and Content Control ($M = 3.14$, $SD = 0.59$) did not significantly differ.

CRYSTAL ISLAND and efferent stance. A preliminary analysis was conducted to examine if there were differences in the distribution of Efferent and Non-Efferent stances at the end of the game between the two CRYSTAL ISLAND conditions (Scaffolding, Non-Scaffolding). Results indicated that students' stances did not differ as a function of condition; χ^2 $(1, N = 65) = 1.25$, $p = .385$. Therefore, there was an approximately equal number of students who took an Efferent and Non-Efferent stance in both the Scaffolding, $n = 16$ and 12, respectively, and Non-Scaffolding conditions, $n = 19$ and 18, respectively. Due to the fact that there were no differences between the two CRYSTAL ISLAND conditions in terms of learning gains and stance, the two conditions were collapsed in subsequent analyses.

To examine the effect that students' stances had on gains in performance on multiple-choice questions, zero-order correlations between stance and standardized residual gain scores (i.e., post-intervention performance controlling for pre-intervention performance) for the factual-level and application-level multiple choice questions were conducted. Zero-order correlations were conducted in preparation for hypothesized mediation analyses, which are to follow. Analyses indicated that stance was positively

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related to residual gains on factual-level multiple-choice questions, $r(64) = .22$, $p = .038$; however, the relation for application multiple-choice questions was non-significant, $r(64) = .15$, $p = .125$. Therefore, taking an efferent stance when reflecting on the CRYSTAL ISLAND interaction was predictive of greater factual-level learning gains.

To examine the effect that students' stances had on post-intervention application-level constructed responses, correlations were conducted between stance and the averaged performance on the two application-level constructed responses. Results indicated that taking an efferent stance when reflecting on the CRYSTAL ISLAND interaction was predictive of better performance on the application constructed responses, $r(64) = .34$, $p = .006$.

CRYSTAL ISLAND in-game performance and science learning. To examine if students' in-game performance predicted standardized residual gain scores on factual-level and application-level multiple choice questions, a series of zero-order correlations were conducted with the independent variable of Goals Completed ($M = 5.88$, SD = 1.27). Analysis indicated that Goals Completed positively predicted factual-level residual gains, $r(64) = .38$, $p = .002$. In particular, completing more goals was associated with greater gains on factual-level multiple-choice questions. Similarly, analysis indicated that Goals Completed positively predicted application-level residual gains, $r(64) = .32$, $p = .009$, such that completing more goals was associated with greater gains on application-level multiple-choice questions.

Lastly, to examine if in-game performance was associated with application-level constructed response performance, a zero-order correlation was conducted. Results

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indicated that both Goals Completed positively predicted transfer performance on application-level constructed response questions, $r(64) = .28$, $p = .022$.

CRYSTAL ISLAND in-game performance and stance. Analyses were conducted to determine if the effect of students' efferent stance and students' learning (i.e., factual multiple-choice scores residual gains and application constructed response scores) was mediated by in-game performance (i.e., Goals Completed). As indicated previously, factual multiple-choice scores residual gains and application-constructed response scores were related to both students' stances and in-game performance. Students' stances were also positively related to in-game performance, $r(64) = .40$, $p = .001$.

As represented in Figure 2, to examine mediation on factual multiple-choice residual gains, a hierarchical regression was conducted with students' stances entered into the equation in the first step and the mediating variable (in-game performance) in the second step. In step 1, taking an efferent stance was positively related to factual multiple-choice gains ($\beta = .22$, $p = .038$). With the addition of in-game performance in the second step, students' stances were no longer significantly related ($\beta = .04$, $p = .754$). Therefore, it is suggested that in-game performance mediated the effect of students' stances on learning gains on factual multiple-choice questions. Using the PROCESS macro (Preacher & Hayes, 2004), bootstrapped indirect effect of students' stance on factual knowledge gains through goals completed was significant with a 95% Confidence Interval of [0.13, 0.70]. Hence, the number of goals completed in-game did significantly mediate the relationship between student stance and learning gains. A commonality analysis was conducted to determine the amount of predicted variance that was shared

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among and unique to stance and in-game performance. Results indicated that the two variables shared approximately 5% of the variance in factual multiple-choice learning gains. Students' stances uniquely explained about 1% of the variance in learning gains, and in-game performance uniquely explained 17% of the variance.

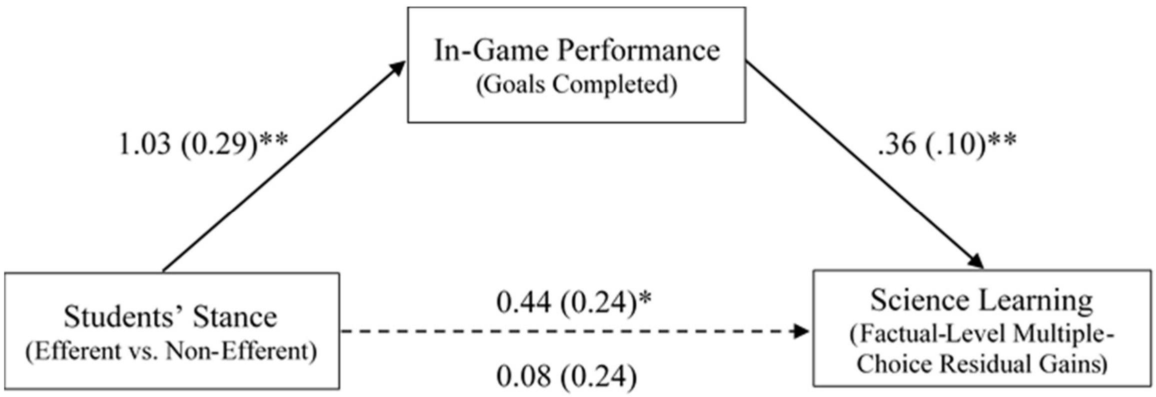

Figure 2. Representation of students' in-game performance mediating the relationship between students' stance and factual-level multiple-choice residual gains. Unstandardized *B* coefficients and standard errors are presented. The coefficient presented above the arrow connecting stance and science learning is the relation between the two variables not accounting for in-game performance. The coefficient presented below the arrow connecting stance and science learning is the relation between the two variables while controlling for in-game performance. Note: $^{**}p < .01$, $^{*}p < .05$.

As represented in Figure 3, to examine mediation on application construct responses, a hierarchical regression was conducted with students' stances entered into the equation in the first step and the mediating variable (in-game performance) in the second

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step. In step 1, taking an efferent stance was positively related to application construct response scores (β = .35, p = .004). With the addition of in-game performance in the second step, students' stances were still statistically significant; however, significance was reduced (β = .28, p = .036). Therefore, it is suggested that in-game performance mediated the effect of students' stances on students' performance on application constructed responses. However, bootstrapped indirect effect of students' stances on application gains through goals completed was significant with a 95% Confidence Interval of [0.11, 0.62]. Hence, the number of goals completed in-game significantly mediated the relationship between students' stances and learning gains. A commonality analysis was conducted to determine the amount of predicted variance that was shared among and unique to stance and in-game performance. Results indicated that the two variables shared approximately 6% of the variance in application constructed responses. Students' stances uniquely explained 6% of the variance in learning gains, and in-game performance uniquely explained 3% of the variance.

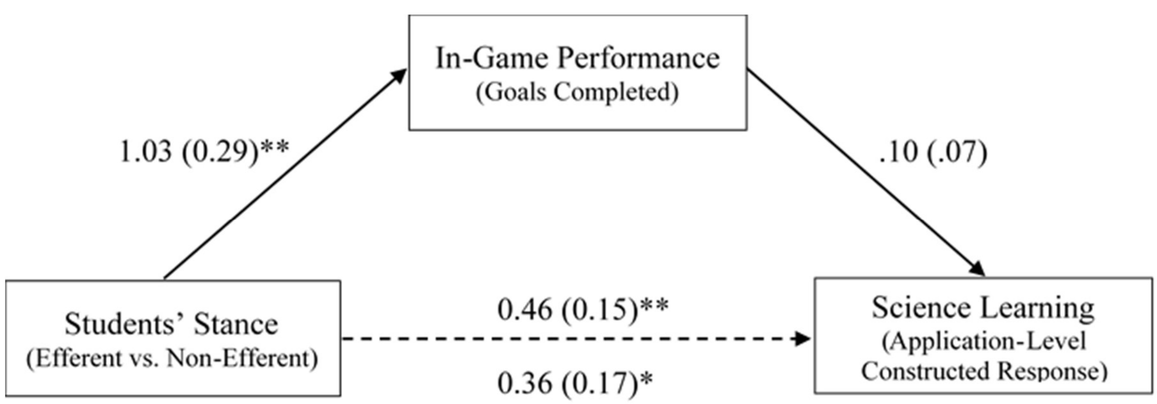

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Figure 3. Representation of students' in-game performance mediating the relationship between students' stance and application-level constructed response scores. Unstandardized *B* coefficients and standard errors are presented. The coefficient presented above the arrow connecting stance and science learning is the relation between the two variables not accounting for in-game performance. The coefficient presented below the arrow connecting stance and science learning is the relation between the two variables while controlling for in-game performance. Note: $^{**}p < .01$, $^{*}p < .05$.

Discussion for Study 2

To explore whether transactional theory could serve as an interpretive lens for narrative-centered game-based learning, efferent scaffolds were embedded within the game in hopes of helping students create an optimal balance among cognitive load and efferent and aesthetic game-player stances. The first step in testing the effectiveness was to examine if students using the CRYSTAL ISLAND learning environment made significant gains in microbiology content knowledge and to see if these gains differed by condition. It was predicted that gains would be greatest for the content-scaffolding condition. Results from Study 2 indicated that there were significant factual and application multiple-choice learning gains in all conditions of the study; however, there was not a significant difference in learning gains as a function of condition. This indicated that students in Scaffolding, Non-Scaffolding, and Content Control (i.e., PowerPoint) conditions knew the microbiology concepts presented better following the intervention. There were also no differences among conditions on the application-level constructed responses developed to assess possible transfer effects. This measure was only presented

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following the intervention, as such conclusions about potential intervention effects on responses to the questions are not able to be assessed.

The second goal of the present study was to explore if individual differences in stance predict effectiveness in gameplay as indicated by learning gains and completion of in-game goals. Contrary to what we predicted, the content-scaffolding condition did not increase the likelihood that a student would take an efferent stance. Nonetheless, results did indicate that taking an efferent stance, compared to a non-efferent (i.e., aesthetic) stance, was positively predictive of learning gains on factual-level multiple-choice questions and of better performance on the application-level constructed responses. Yet, this relation was not present for application multiple-choice questions. In addition to learning gains, results also indicated that students' stances were related to in-game goals completed. In particular, students who took an efferent stance were more likely to complete more of the in-game goals compared to their non-efferent counterparts.

Lastly, it was Study 2's goal to examine if the stances that students brought to the learning interaction influenced their completion of in-game goals, which in turn affected their learning gains. An initial step required to test the proposed mediation analyses involved establishing that in-game performance (Goals Completed) was related to the learning outcomes that were predicted by stance (i.e., factual multiple-choice residual gains and application constructed response score). The number of goals completed positively predicted both learning outcomes. Subsequent mediation analyses indicated that in-game performance mediated the relation between stance and factual multiple-choice gains as well as the relation between stance and performance on the application-

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constructed responses. In particular, it was found that students who took an efferent stance, as opposed to a non-efferent stance, were more likely to complete more of the game's goals, which in turn predicted greater performance on the learning outcomes. In other words, how students approached the learning environment (i.e., stance) affected how they interacted with the environment and in turn how much of the microbiology lesson they learned.

The results from Study 2 help provide insights into understanding how students approach interactive learning environments directly affects how they interact with and learn from these environments. Interestingly, the present studies' attempt to experimentally manipulate students' stances through in-game scaffolds were not successful. Contrary to what was hoped, students in the Scaffolding condition were not more likely to take an efferent stance than students in the Non-Scaffolding condition. As such, further experimental research is needed to examine if students' approach to interactive learning environments can be influenced to focus in on the efferent or learning aspects of the environment.

General Discussion

The overall goal of the studies presented was to investigate how theoretical perspectives from the literacy field, specifically transactional theory (Rosenblatt, 2004), could potentially benefit game research. Utilizing CRYSTAL ISLAND, a narrative-centered learning environment, we examined how the game affected eighth-grade students' content-based learning of microbiology.

As demonstrated by our study, narrative-centered learning environments pose a

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challenge to designing games which are simultaneously effective learning tools and engaging. To meet this challenge, an iterative design approach was used to create the game, implement it with students, and then refine the game. This design approach has led to theoretical and practical implications for game design and classroom implementation.

Findings Related to Cognitive Load Theory

As mentioned earlier, CRYSTAL ISLAND, as a game, is a multimodal text as well as a multimedia learning environment. As such, it allows users to interact with printed text, images, movements, and sound to derive meaning from the messages conveyed throughout the game. If the interactions of these various modes and media are not well-designed or controlled, users may experience cognitive overload (Keller, 2008). However, cognitive load theory (Sweller, 2005) notes that learning, or acquiring and automating new schemas, can be made easier for students if the instructional methods used reduce students' cognitive load (Chandler & Sweller, 1991; Mousavi, Low, & Sweller, 1995; Tindall-Ford, Chandler, & Sweller, 1997). Research has shown that using multimodal instructional tools appropriately can reduce cognitive load by reducing demands on the students' working memories, thereby helping them learn faster (Mayer, 2014; Mousavi, Low, & Sweller, 1995; Oviatt, Coulston, & Lunsford, 2004). During Study 1, two versions of CRYSTAL ISLAND were used—Narrative and Narrative-Light—in order to examine how the narrative feature of the game affected student learning. As seen in the results of Study 1, students in the Narrative condition had significantly fewer learning gains than students in the Narrative-Light or Content Control conditions,

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indicating that the students in the Narrative condition may have experienced a heavier cognitive load than those in the other conditions.

In order to lessen the cognitive load, the narrative condition was minimized in the second study and efferent content scaffolding was added to help reduce demands on students' cognition. This proved successful, as the Study 2 results showed no significantly different learning gains between students in the Content Control condition or the students who were in either of the conditions using CRYSTAL ISLAND, Scaffolding or Non-Scaffolding. The Study 2 results differed from Study 1, which indicated students in the Content Control condition had more significant learning gains than the Narrative and Narrative-Light conditions.

Findings Related to Transactional Theory

The Scaffolding and Non-Scaffolding conditions were created following the Think-Aloud Protocols (TAPs) held during Study 1 using Rosenblatt's (2004) transactional theory. We examined the TAPs and developed the new efferent content scaffolding conditions in order to know more about how these scaffolds might affect students' approaches to interactive learning environments and how they interact with and learn from these environments. Though we hypothesized that the efferent content scaffolding would help students focus more on the science content and adopt an efferent stance more often within game and in the recall of the game, results did not support this hypothesis. However, we did find that the students who adopted an efferent stance in their recall completed more in-game goals, which was related to more significant learning gains in regards to both factual, multiple choice content and application constructed

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content. The current findings differ from those of McEneaney et al. (2009), who found that readers with an aesthetic stance demonstrated higher understanding of nonliterary hypertext. A possible explanation for the current study's finding in relation to game-based learning is that players whose recall indicates they take an efferent stance are more well-suited to learning conditions within a game-based environment. Future research should examine this finding further.

Limitations

All studies have limitations, and the current study is no exception. First, using multiple-choice responses to measure complex inquiry and cognition processes within a digital learning environment like CRYSTAL ISLAND poses issues. As Schaffer, Hatfield, Svarovsky, Nash, Nulty, & Bagley (2009) noted, "Assessments of digital learning need to focus on performance in context rather than on tests of abstracted and isolated skills and knowledge" (p. 34). Using student trace data for analysis offers future occasions to use evidence-centered design, which aligns learning theory and assessment method. Additionally, future CRYSTAL ISLAND studies will use transfer measures to measure how well students apply the information in the game to new learning contexts.

Another limitation with this study is that, although the game is a narrative-centered learning environment, CRYSTAL ISLAND does not provide the visual engagement and action that commercial games offer. The lack of action and visual stimulation when playing academic games can be disappointing to students, who are accustomed to a higher level of entertainment and engagement.

Lastly, a limitation regarding stance is that those results (including the mediation

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analyses) are correlational. We cannot determine that stance caused differential learning gains. Future research should explore if we can manipulate stance and if inducing a more efferent stance yields greater gains.

Conclusion and Future Research

The current study corroborated existing results that game-based learning not only improves students' motivation and engagement with content, but also helps students learn new information (Zhonggen, 2019; Lester, Spires, Nietfeld, Minogue, Mott, & Lobeni, 2014; Perrotta et al., 2013; Wouters et al., 2013). As seen in our study, game designers must consider a game's cognitive demand on students, as overusing multimodal tools or narrative elements may result in fewer learning gains. Games must be purposefully and carefully designed to manage the cognitive load required by the content without increasing the cognitive load needed to navigate the features of the game. Of particular note, this study also explored how transactional theory, from the literacy field, may be used as a theoretical lens to interpret how gameplayers' stances affect game play and learning.

Future research with CRYSTAL ISLAND will involve more in-depth analyses of in-game performance and how it relates various pedagogical game features and learning outcomes. We will continue to explore how transactional theory can be used to understand students' approach to gameplay using a combination of aesthetic and efferent stances. No solitary educational approach, including game-based learning, is successful for all students or across all subjects. As the world is moving more toward apps, social media and handheld devices, the methods of and obstacles to learning will continue to

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change. Research on game-based learning must continue to focus on what works in, with whom, and in which context. Adequately addressing this concern will result in games that are more compatible with school contexts, which may result in a greater impact on the development of students' literacy skills and dispositions.

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