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Journal:	*Library Hi Tech*
Manuscript ID	LHT-01-2019-0010.R2
Manuscript Type:	Original Article
Keywords:	Serious games, Information literacy, Research skills, Library instruction, Learning, Game-based learning

Serious Games for Information Literacy: A Scoping Review and Design Recommendations

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Abstract

Purpose: This paper provides an overview of the literature on digital games designed or adapted for information literacy instruction, as well as practical design recommendations.

Design/methodology/approach: The paper presents an analysis of a compiled set of peer-reviewed articles on games in the provision of information literacy instruction published between 2013–2018, categorized by game mechanics utilized.

Findings: Application of the inclusion criteria led to 12 papers considered relevant. Synthesis of the papers suggests that although studies indicate positive outcomes for information literacy games, such games continue to rely on transcription of declarative tasks to digital environments.

Originality/value: While previous literature reviews provide summaries on information literacy digital games, this paper not only presents an up-to-date review but also provides step-by-step instructions and worked examples for aligning information literacy learning mechanics with game mechanics.

Keywords: Serious games, Information literacy, Research skills, Library instruction

Introduction

In a report released on January 10, 1989, the American Library Association's Presidential Committee for Information Literacy recognized that "(i)nformation is expanding at an unprecedented rate, and enormously rapid strides are being made in the technology for storing, organizing, and accessing the ever growing tidal wave of information" (para. 1). Twenty years later, during the proclamation of National Information Literacy Awareness Month, U.S. President Barack Obama stated that "we must...learn the skills necessary to acquire, collate, and evaluate information for any situation" (2009, para. 1).

Although a U.S. president's proclamation (2009) indicates growing interest in information literacy, educational gaps still need to be addressed—especially skills for conducting research. Despite librarians' roles in information literacy education, college students rely on librarians infrequently, if ever, when conducting research for course work (Head & Eisenberg, 2010). Even when students do receive resource-focused instruction from librarians, many continue to lack the ability to control and manage the resulting information overload that comes with inquiry (Head & Eisenberg, 2010). This challenge may be due to limited contact between students and librarians. Frequently, contact is restricted to "one-shot" training sessions that are intrinsically dull to many students (Smale, 2011). This challenge raises the question: What additional tools might enhance information literacy education?

Game-based Learning and Information Literacy

The excitement surrounding digital games for educational, behavioral, or social outcomes has increased over the last decade. Rather than being merely entertaining, digital games encourage principles of learning—principles that are often better than skill-and-drill lessons (Gee, 2003). Although many designers create game-based learning applications to support

players in carrying out specific tasks efficiently, others games have fostered higher-level thinking such as analysis, evaluation, and creation (Connolly, Boyle, MacArthur, Hainey, Boyle, 2012).

This interest in supporting lower- as well as higher-order thinking skills using digital games has increased in the field of information science, as well. Smale (2011) noted that gaming in libraries (and the literature on this trend) has increased over the last decade. Accompanying this trend has been an increase in digital games designed or adapted for information literacy instruction (Smale, 2011; Broussard, 2012). There has been limited exploration, however, of which game features most effectively promote engagement and support learning (Boyle et al., 2016). As educators adopt digital games for information literacy instruction, future designers and researchers will benefit from a review of the current literature on information literacy games and the subsequent design considerations it yields.

Aim of the Current Paper

The aim of the current paper is to:

1. Provide a scoping review of digital games developed or adapted for information literacy instruction for both K-12 and higher education within the last five years, specifically focusing on game mechanics utilized, and
2. Contribute design recommendations for future developers and researchers.

To illustrate how to use these design recommendations, this paper provides worked examples from the early design and development phases of *The Chroniclers*, a middle-school social science and information literacy video game.

Definitions

Information literacy.

For the purposes of this research, the term information literacy refers to the Association of College and Research Libraries' (ACRL) expanded definition:

> Information literacy is the set of integrated abilities encompassing the reflective discovery of information, the understanding of how information is produced and valued, and the use of information in creating new knowledge and participating ethically in communities of learning. (para. 6, 2016)

This holistic definition can be applied to almost any digital information literacy game and is not bound solely to college or research libraries.

Previous Research

This research builds upon previous literature reviews on the intersection of digital games and information literacy. Smale (2011) provided a summary of applicable literature published up until 2010 on digital games for information literacy instruction. She detailed research on digital game-based learning and then provided a synopsis of commercial games used for, games specifically created for, and game principles for information literacy instruction. Later, Broussard (2012) provided an overview of online library games, as well as best practices for future designers. Although both Smale and Broussard reported on the varied success or impediments to the development of the games they reviewed, their valuable summaries do not detail how the chosen game mechanics supported information literacy learning outcomes. Without detailing the mapping between player behavior, specific mechanics, and intended outcomes, it may be difficult to measure the efficacy of information literacy games. This sentiment echoes the assertion made by Markey, Leeder, and Reih (2014), creators of the game *BiblioBouts*: although state-of-the-art literature reviews of educational games show promise,

specific "evaluations of online information literacy games do not yet provide convincing evidence of their effectiveness" (p. 228).

Significance

This paper continues the work of Smale (2011) and Broussard (2012), providing other researchers and practitioners an up-to-date review of digital games for information literacy instruction from the last five years. The findings of this research, in turn, inform possible design recommendations for practitioners and domain experts (such as librarians).

The Scoping Review

To compile a set of peer-reviewed articles on the use of games in the provision of information literacy instruction, a university reference librarian assisted in building the Boolean logic and targeted databases. Additionally, each paper had to be (a) published between January 2013 and October 2018, (b) published as a peer-reviewed article or conference proceeding, (c) written in English, and, finally, (d) include an abstract. The date of the latest search was on November 5th, 2018.

In total, 181 records were identified within the five-year time period with duplicate records removed. An additional record was identified through bibliographic review.

Papers Excluded

After screening by title and abstract for relevance, I excluded 144 articles, winnowing the applicable papers to 37. I then excluded 25 papers for the following reasons: (a) lack of applicability to information literacy education, (b) focus on non-digital games, (c) emphasis on digital literacy, (d) significant lack of detail, (e) the game analyzed was created prior to 2013, or (e) the investigation was concerned more with *gamification* rather than *game-based learning*. Gamification is typically seen as the trend of including game design elements in non-game

contexts (Deterding, Dixon, Khaled, & Nacke, 2011). This could include superimposing a badging system or leaderboard to an information retrieval system rather than embedding mechanics to overcome challenges. Game-based learning, on the other hand, engages players to reflect on strategy to complete these challenges, encouraging the player figure out and use the game's rules to their own advantage (Gee & Hayes, 2012).

Results of the Scoping Review

Papers Selected

Using the inclusion criteria defined, 12 papers met the inclusion criteria and were identified as relevant to the current review: they described and evaluated a digital game that was developed or adapted for the transfer of information literacy skills. In total, these articles outlined nine distinct games.

Categorization of Papers

Previous literature reviews categorized their findings by the designers/developers of the identified game, the type or format of the game (e.g., alternative reality, role-playing, puzzle, etc.), and the intended outcomes of the game (Smale, 2011; Broussard, 2012). Such a format provides a quick review of the state of the field. However, because it is crucial to understand how different gaming elements contribute to learning (Arnab et al., 2015), the current review attempts to extend the work of previous literature reviews by highlighting, as much as possible, the mechanics of each game and how they support designated learning outcomes. To accomplish this categorization, this paper utilizes the Arnab et al.'s (2017) Learning Mechanics and Game Mechanics model to better map gaming content with human behavior for each presented game.

Categorizing with the Learning Mechanics and Game Mechanics Model.

The Learning Mechanics and Game Mechanics model is a game-play analysis, as well as a conceptual design tool (Arnab et al., 2015). For the purposes of the scoping review, the model is used as an analysis tool, attempting to map in-game actions to pedagogical intents—the first step in the model. Figure 1, which represents possible learning and game mechanics, aids in this process.

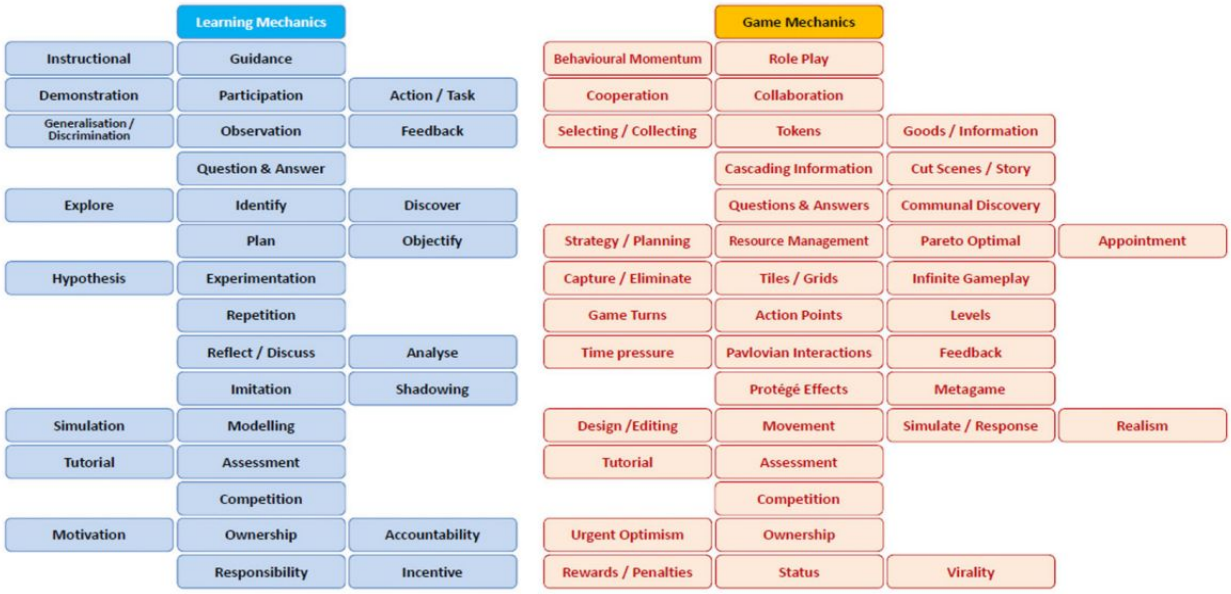

Figure 1: Designers may use these pre-determined learning and game mechanics to analyze or design educational games (Arnab et al., 2015).

Although there is no singular definition of learning, learning mechanics (e.g., discover, assess, experiment) represent a range pedagogical intents derived from 21st century pedagogy (Arnab et al., 2017). Designers may link game mechanics (e.g., gathering, rewards, role playing, levels) to these pedagogical intents to aid players in reaching designated learning outcomes. Arnab et al. (2015) tested this model through case studies, as well as a comparative analysis with other frameworks, and found it to be a tool that designers and domain experts, such as librarians and partnering classroom teachers, may easily use. Arnab et al. (2017) explained how to read this model with its two axes:

> On the horizontal axis lie the learning and game mechanics analogous to a breadth-first search. Core components run vertically down from the two root nodes (of learning mechanics and game mechanics respectively) in a manner similar to a depth-first search. Side or leaf nodes represent functional mechanics supporting the core. (p. 396)

Designers may then begin to coordinate which mechanics will support each other, or, in this case, a reviewer may use the model to analyze games. Although this model is not exhaustive or prescriptive, it establishes mechanics that frequently appear in educational games.

Based on the descriptions provided in each identified paper, I first categorized each game based on genre. Each game description includes a list of game mechanics specifically outlined in each paper. See Table 1, which summarizes these mechanics. In instances where the presented game did not succinctly fall within one particular genre, I categorized the game according to the emphasis authors placed on specific mechanics.

Text-based Adventure Games

For the purposes of this paper, I define text-based adventures as games that convey story and learning content primarily through a static, text interface. This style of game may also include embedded multimedia. Three games, *Lost in Antarctica, Agoge: The Spartan's Journey,* and *The Legend of Zyren*, fit this description.

Eckardt and Robra-Bissantz (2016) described their design process for *Lost in Antarctica*, which positions players as crash-landed scientists at the southern pole. *Lost in Antarctica's* target audience are college-level engineering students. This 2D prototype includes avatar creation, video presentations, and accompanying crosswords, memory games, and similar tasks for declarative knowledge transfer. To win *Lost in Antarctica*, students complete these team-

based, instructional games. The authors, however, do not detail which specific information literacy concepts these mini-games test.

Kearns, Breanne, and Cononie (2017) designed *Agoge: The Spartan's Journey* to bridge the gap for transferring university students who often miss library orientation classes. This game follows a set of linear scenes within which players complete quiz tasks (e.g., multiple-choice exercises) and receive feedback. Players must select embedded objects in *Agoge*'s 2D environment to reveal these tasks. Topics included in this game range from database use to proper citations. *Agoge* utilizes the gaming technique of gating, which prevents players from progressing until they successfully complete each level's tasks. After completing each level, *Agoge* rewards players with virtual Spartan gear. These levels correspond with the five ACRL *Information Literacy Competency Standards for Higher Education* (2000). The authors note, however, that future developments could incorporate the newer ACRL *Framework for Information Literacy for Higher Education* (2016).

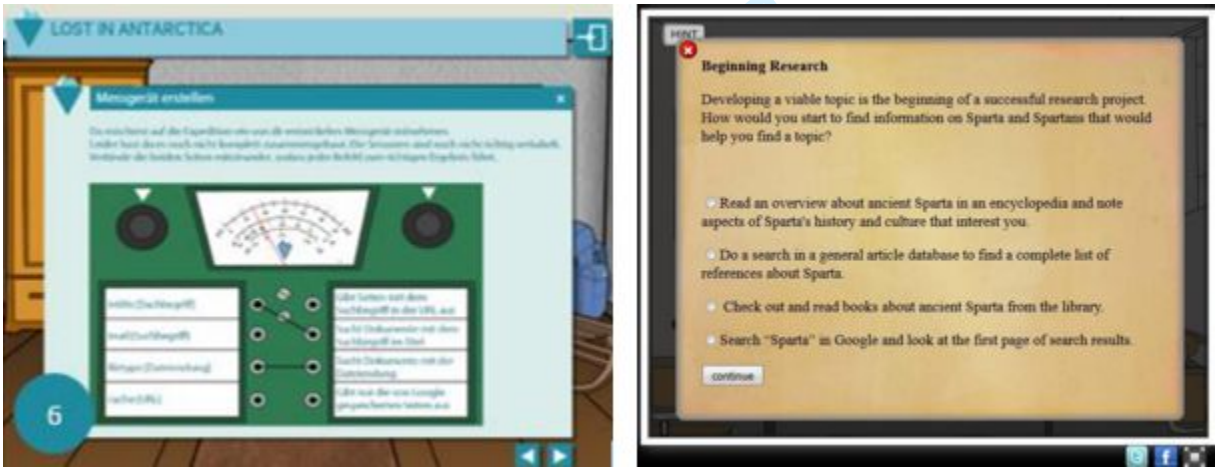

Figure 2: Left: A matching question found in *Lost in Antarctica.* Right: A multiple-choice question from *Agoge*, asking the player the best techniques for starting a research project.

Knautz, Wintermeyer, Orszullok, & Soubusta (2014) created *The Legend of Zyren*, a fantasy game designed for a mandatory, college-level course on knowledge representation. Players create avatars and gain experience points as they successfully complete in-game quests.

These quests include automatically graded multiple-choice tasks and writing and research tasks that require instructor assessment. To pass the course, players must accrue a designated amount of experience points. Students who attain more than the designated amount receive bonus points on their final exam. Although the authors described student grades and evaluations, they did not detail the learning content conveyed through *Zyren*.

Graphic Adventure Games

Graphic adventure games employ multimedia to simulate physical movement throughout a story environment where players solve puzzles and other challenges. Four games, *Library Escape, The Detective: Verona*, *The Detective: Bavaria*, and *Wisdom Town* use this approach to teach information literacy concepts.

Guo and Goh (2014, 2016a, 2016b) and Guo, Goh, and Luyt (2017) describe the design of and research using *Library Escape*. Designed for college students, *Library Escape* is a single-player game in which the user progresses through six distinct missions to escape a haunted library. The designers drew inspiration from Kuhlthau's Information Search Process model (2004), which outlines six stages of the research process and its accompanying emotions. In *Library Escape*, the player explores levels to find items that contain instructional content on topics ranging from library anxiety to citation pearl growing. To progress through each level, the player must answer three to five quiz questions, which are typically fill-in-the-blank, multiple-choice, or sorting questions. Players cannot progress until they answer all the questions correctly, and they have one hour to complete all six levels.

Wilson et al. (2017) embedded information literacy instruction into two, point-and-click mystery games, *The Detective: Verona,* inspired by Shakespeare's *Romeo and Juliet,* and *The Detective: Bavaria*, which draws upon Shelley's *Frankenstein*. Combined, these games for high school students cover topics ranging from authority and objectivity to data-interpretation tasks.

In *Verona*, players collect, evaluate, and organize clues to refute or substantiate hypotheses in scaffolded learning scenarios. Upon collecting an item, the game asks players to determine whether the clue is credible or unreliable. If the player determines that the clue is unreliable, they must provide an explanation using one of five predetermined answers based on authority, verifiability, objectivity, timeliness, or detail. The game then provides feedback to reinforce player behavior or to assist the player with direct instruction.

The Detective: Bavaria uses a format similar to *Verona*, but players must instead evaluate types of data (e.g., qualitative/quantitative, primary/secondary) and their impact on hypotheses. Specifically, students must select implications of pieces of data in a question and answer format. Next, players determine if the clue supports, opposes, or is irrelevant to the presented hypothesis.

Figure 3: Library Escape (left) and The Detective: Verona (right) simulate physical exploration. In Verona, players search the environment for evidence to substantiate or refute claims.

Wu, Li, & He (2016) assessed their prototype, *Wisdom Town*, an adventure game that promotes undergraduate procedural knowledge of commonly used research databases. To progress through this fantasy game, players must collect a series of objects. In order to gain these objects, the player must engage with non-player characters and answer questions

regarding journal databases. *Wisdom Town* also uses the technique of gating, where, if the player does not succeed in answering the questions correctly, the player must restart the level. Although the authors outline how they developed *Wisdom Town*, they do not specify how these non-player characters test player knowledge or other in-game mechanics.

Competitive Games

Of the literature selected for this review, only Shmelev, Karpova, Kogtikov, & Dukhanov (2016) describe a competitive information literacy game. They created a game-based search engine specifically designed to improve the search skills of graduate-level students. This search engine provided tasks, hints, points, and a time limit for completing each task. The game categorized these tasks by complexity, from low-complexity (e.g., finding information in a specific article) to high-complexity (e.g., having to search through article references to string together information from multiple sources). After players completed these timed search tasks, the game presented the teams with performance statistics.

Figure 4: Answer input form and in-game statics for the game-based search engine.

Sandbox Games

Sandbox games are typically 3D virtual worlds with limited-to-no story. Instead, they emphasize player-inspired creativity. *Minecraft* is an example of a commercial sandbox game. Hill (2016) used *Minecraft* in a fifth-grade, after-school library program. Hill conducted observations of fifth-grade students using *Minecraft* to design a 3D virtual library. Students assumed project roles to develop this library, which they filled with secret treasure only accessible by answering information literacy and digital citizenship questions. After constructing this virtual library, the fifth-graders conducted user evaluations with younger students.

Mini-games

Cowing (2017) relates his process of prototyping mini-games for library instruction. He designed this interactive instruction for undergraduate students taking a mandatory, one-credit college course on information literacy. Unlike the other identified games, Cowing did not include an overarching narrative. Instead, players completed a series of small challenges. These challenges included multiple-choice questions, a virtual scavenger hunt, text-entry questions on source selection, and a citation "clean-up" exercise.

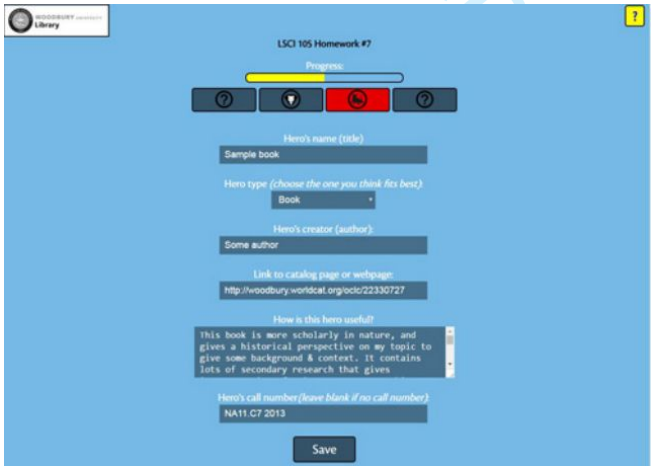

Figure 5: Players use text-entry boxes to provide information on source selection and justification. Player progress is depicted at the top of the screen.

Table 1

Each game identified and its described game mechanics.

Game Title	Game Mechanics Utilized
Lost in Antarctica	Role Play, Ownership, Cooperation, Movement, Cut Scenes/Story, Collecting/Selecting, Question & Answer, Reward
Agoge: The Spartan's Journey	Cut Scenes/Story, Question & Answer, Reward/Penalties, Feedback, Points, Levels, Tokens
The Legend of Zyren	Cut Scenes/Story, Role Playing, Question & Answer, Reward/Penalties, Pavlovian Interactions, Tokens, Feedback, Status
Library Escape	Cut Scenes/Story, Exploration, Questions & Answer, Levels, Feedback, Time Pressure
The Detective: Verona and *Bavaria*	Movement, Cut Scenes/Story, Selecting/Collecting, Levels, Tutorial, Question Answer, Feedback
Wisdom Town	Cut Scenes/Story, Collecting, Levels, Feedback
Competitive search engine	Cooperation, Time Pressure, Strategy Competition, Resource Management, Capture/Eliminate, Rewards/Penalties, Feedback
Minecraft after-school program	*Builders:* Strategy/Planning, Design/Editing, Ownership, Cooperation *Players*: Exploration, Question & Answer, Rewards
Cowing's mini-games	Questions & Answer, Movement, Strategy/Planning

Summary of Game Mechanics Utilized

Similar to Smale's (2011) literature review, many of the identified games asked students to solve a mystery by finding information or completing a scavenger hunt. Although the identified authors generally indicated that digital games might yield positive impacts for information literacy instruction, future papers may benefit from detailing how game mechanics linked to specific learning mechanics. The papers that did outline these connections typically relied on transcribing declarative learning tasks to digital environments, often through employing multiple choice, true/false, or other question and answer mechanics. According to Anderson (2008), information literacy requires procedural skills that necessitate complex levels of thinking and knowledge. Multiple-choice questions alone cannot support higher-order

learning outcomes. As such, continued investigation into game-based learning that promotes analysis, evaluation, and synthesis might benefit the field.

The new field of information literacy games, still attempting to establish clear connections between game mechanics and higher-order learning outcomes, presents an opportunity for future designers. By applying models at the conception of game design, future designers may create even more engaging spaces that promote reflection on the research process, as well as active construction of new information.

To assist future designers in creating information literacy games, the following section of this paper outlines how to better link game mechanics with learning mechanics. I present three general steps for creating these connections. These steps draw from the strengths identified in the scoping review, as well as my own experience in the early design and development phases of *The Chroniclers*, a middle-school social science and information literacy video game.

Design Recommendations for Future Information Literacy Games

One of the primary challenges in game-based learning is aligning principles and mechanisms with particular subject matter content and skills (Graesser et al., 2009). Without thorough investigation of which mechanics support information literacy skills, such as analysis and evaluation, designers continue to run the risk of forcing traditional, declarative tasks into digital games, which, at their heart, should be problem-solving spaces (Gee, 2009). After choosing their target audience and learning objectives, future designers may benefit from the following steps: (1) framing the game within a specific information literacy model, (2) including student reflection and performance-based information literacy tasks, and (3) connecting game mechanics with learning mechanics.

For *The Chroniclers*, we (1) used the Guided Inquiry Design Process (Kuhlthau et al., 2012) to direct the game flow of actions, (2) drew inspiration from Gordon's (2009) performance-based information literacy tasks to create these actions, and (3) utilized the Learning Mechanics and Game Mechanics model (Arnab et al., 2015) to detail the implementation of these actions.

Game Prototype: *The Chroniclers*

The Chroniclers is a 3D graphic adventure prototype intended to teach both information literacy and world history to middle-school students. Without information literacy, names, dates, and events may be simply accepted and tossed aside after each lesson. In this single-player game, students play as time-travelling guardians of history who solve problems in various ancient settings. To solve these problems, players must gather, evaluate, and, most importantly, create new information by grappling with sources that illustrate historical context and perspectives.

Because *Chroniclers* is currently in its initial design phase at a game research and development facility**,** we have not yet assessed the game mechanics included in our prototype. Instead, I present the steps we have used thus far to ensure that game mechanics match intended learning objectives. These steps may assist future designers, as well.

Step 1. Framing the Game within an Information Literacy Model

Figure 6: Cut scene introducing The Chroniclers.

Prior to selecting particular game mechanics, future designers may benefit from choosing specific information literacy standards or models to direct the flow of in-game actions. Only a handful of the identified articles described a theoretical lens, framework, or educational standard for developing their game. These articles include Guo and Goh (2014, 2016a, 2016b) and Guo, Goh, and Luyt (2017), Wilson et al. (2017), Kearns, Breanne, and Cononie (2017), and Hill (2015).

To structure the flow of *Chroniclers*, we adopted the Guided Inquiry Design Process (Kuhlthau, Maniotes, and Caspari, 2012). Kuhlthau, Maniotes, and Caspari (n.d.) created the Guided Inquiry Design Process to embody a student's "process of learning from a variety of information sources in extensive research projects" (para 1) within eight steps: open, immerse, explore, identify, gather, create, share, and evaluate.

The Guided Inquiry Design Process evolved from Kuhlthau's Information Search Process Model. The Information Search Process Model depicts how knowledge connections form, emphasizing how "uncertainty, both cognitive and affective, increases and decreases in the process of information seeking" (Kuhlthau, n.d., para. 19).

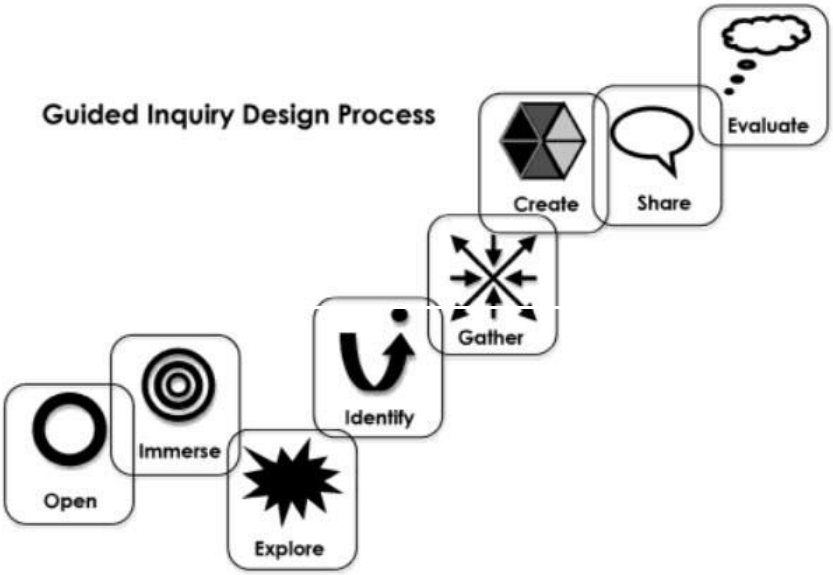

Figure 7: The eight steps of the Guided Inquiry Design Process (Kuhlthau, Maniotes, and Caspari, 2012, p. 31).

This waxing and waning of uncertainty leads to self-assessment and self-adjustment throughout the search process. Guo and Goh (2016) used the Information Search Process Model to design their six, in-game missions for *Library Escape*. However, Kuhlthau designed the Information Search Process model to convey emotions throughout the search process. Therefore, we instead selected the Guided Inquiry Design Process, which was designed to embody student learning. Furthermore, the Guided Inquiry Design Process also allows for a relatively linear series of in-game actions.

In *Chroniclers*, the player assumes the role of a new recruit tasked with traveling through time to correct disruptions in history caused by the game's antagonist, Ptolemy Soter I. Soter, attempting to recreate the Great Library of Alexandria, disrupts time and endangers the entire universe. The player visits seven ancient settings while chasing Soter, experiencing all eight steps of the Guided Inquiry Design Process in each setting.

Choosing an information literacy model to structure the game, we then created guiding documents to situate the ensuing game and learning mechanics for each setting. See Appendix A for an example of one of these documents.

Figure 8: Left: The Historian's Universal Base (HUB). From this 3D environment, players choose their next mission. Right: Players experience seven different ancient settings: Mesopotamia, Egypt, India, China, Greece, Kush, and Mesoamerica.

Step 2. Incorporating Student Reflection and Performance-based Tasks

With an identified information literacy model and guiding documents, future designers might now more easily incorporate performance-based, information literacy tasks within their prototype. To prevent falling into the temptation of simply translating declarative knowledge assessments (e.g., multiple-choice questions) into *Chroniclers*, we drew inspiration from Carol Gordon's (2009) emerging theory on evidence-based practice for information literacy instruction.

Gordon (2009) proposes that information literacy instructors create classroom decisions based on continuously generated evidence of student work. This evidence-based assessment represents a shift in information literacy instruction from "teaching information skills in isolation to an integrated approach that facilitates the information to knowledge connection" (p. 58, 2009). As students conduct research, they experience waxing and waning uncertainty, which leads to self-assessment and self-adjustment. Gordon (2009) recommends that literacy instruction should include challenges that require students to attend to feedback and make corrections where necessary. Feedback is an essential element of game-based learning, and thus lends itself to information literacy games that create in-game evidence for assessment.

Incorporating evidence of student work and self-assessment may be accomplished through role-playing games. According to Gordon (2009), an authentic learning task could situate the learner in a real-life scenario, such as a rescue worker sent to a natural disaster site to make recommendations on types of aid to help victims. We take a similar approach for *Chroniclers*. For example, students visit ancient Mesopotamia, where they must help non-player characters reestablish their civilization after the havoc caused by the game antagonist, Soter. After initially exploring the destruction wrought by Soter, players must return to their headquarters, the Historian's Universal Base. Rather than simply jumping into the action of

gathering evidence and completing tasks, players must first reflect on their initial exploration with Galileo, a non-player character designed to offer assistance throughout *Chroniclers*. At headquarters, players work with Galileo to select an initial research question (e.g., "How can we ensure the population has a grain surplus?"). See Appendix A for greater detail on these in-game actions.

Figure 9: Left: Players explore a deserted Mesopotamian village where they gather evidence for their research question. Right: Galileo, a non-player character, guides players through their exploration.

Having reflected and chosen a research question, players must then show evidence of their research throughout gameplay. Gordon (2009) suggested that, in order to have continuous assessment in her rescue workers scenario, students write commentary on images they gather of the disaster they are researching. For *Chroniclers,* we take a similar approach. Players must complete text entries in their personal, in-game journal after each task (e.g., learning how to construct a canal). In their journals, players must reflect on how their experience will inform future database searches once they return to the Historian Universal Base. See Appendix A, *Detailed Description* under Row *Gather* for more information on this process.

These two examples from *Chroniclers* are approaches we have initially included to conduct assessment throughout gameplay. Gordon (2009) notes that other formative assessments could be blogs, checklists, peer-reviews, self-evaluation charts, etc. Future

designers could weave these performance-based, formative assessment techniques iteratively throughout the flow of gameplay.

Step 3. Connecting Game Mechanics with Learning Mechanics

Once designers choose an approach for promoting reflection and assessment within their selected information literacy model, they may begin aligning specific game mechanics with learning mechanics. To juggle both social studies as well as information literacy outcomes, we utilized the Learning Mechanics and Game Mechanics model (Arnab et al., 2015) when conceptualizing *Chroniclers*.

Future game designers should note that the Learning Mechanics and Game Mechanics model is not meant to be a "silver bullet" for creating games. As Arnab et al. (2017) notes, naively transcribing instructional methods to game-based learning may be detrimental to gameplay. Instead, this model simply allows users to freely relate mechanics and learning by drawing a map and filling a subsequent table (Arnab et al., 2015). The following sections describe how future designers can create such a map and table. To aid in this process, I present how we aligned mechanics for *Chroniclers*. See Table 2, which represents a portion of this alignment. Appendix A presents the full alignment table we created in order to conceptualize a single level in *Chroniclers*.

Applying learning mechanics within an information literacy model.

Because the traditional Learning Mechanics and Game Mechanics model (Arnab et al., 2015) does not include space for overarching learning theories or frameworks, future designers may benefit from modifying Arnab et al.'s (2015) table. For *Chroniclers*, we first created a row for each step of the Guided Inquiry Design Process. Next, we selected pre-established learning mechanics that correspond with these rows, but future designers may choose to create their own

learning mechanics. (Return to Figure 1 to review these pre-established mechanics.) For the Guided Inquiry Design Process phase of *Create*, for example, we envisioned players watching tutorials on constructing database searches, selecting information to answer a designated research question, and creating infographics to present their findings. With this general idea established, we placed the learning mechanic *Observation*, *Demonstrate*, and *Analyze* within this table. We then completed this process of applying learning mechanics for each step of the Inquiry Process.

Aligning game mechanics and outlining implementation.

Future designers may then benefit from selecting which game mechanics readily align with their chosen learning mechanics. To do this, designers may once again choose from the pre-established game mechanics created by Arnab et al. (2015) or create their own. With our learning mechanics established for database searches and infographic creation, we selected the game mechanics *Selecting/Collecting, Goods/Information,* and *Design/Editing* and then placed these actions in their own column. We then briefly outlined how to implement this learning mechanic and game mechanic connection in the following column, *Implementation*.

Adding detailed descriptions.

The next step in utilizing the Learning Mechanics and Game Mechanics model (Arnab et al. 2015) is providing detailed descriptions of the envisioned implementation. For *Chroniclers*, I describe how players will conduct research using a level-specific, in-game database. Galileo, the non-player character guide, instructs players on how to construct Boolean search strings for this database. After finding information to answer their research questions, players choose infographic templates to present their findings. These templates include areas for text entry and placement of tokens earned throughout gameplay.

Table 2

A portion of the mechanics alignment table for *Chroniclers*.

Part 6: *Create*		
Learning Mechanic	*Game Mechanic*	*Implementation*
– Observation – Demonstrate – Analyze	– Selecting/Collecting – Goods/Information – Design/Editing	– Extensive database searches – Infographic construction – Instructions from Galileo
Description: After completing designated number of tasks in the new inquiry zone, the player returns to the HUB to begin database searches. The searches should be informed by their gameplay experience and chosen tokens. This research is done in-game using a pre-programmed database. Galileo guides the player through constructing a Boolean search strings for this database. The player then conducts searches on his own, selecting information to help answer his research question. Once the player indicates that he has gathered enough data, Galileo reappears. It instructs the player to choose an infographic template in which to write their answers. In this template, the player also places the tokens they earned by completing tasks in Mesopotamia.		

Mapping mechanics in a game flow.

The final step in using the Learning Mechanics and Game Mechanics model (Arnab et al., 2015) is mapping the game mechanics appearance during the game flow of actions. This map should provide a "dynamic view of the relationships as it allows drawing the [learning mechanics] and [game mechanics] in the various phases of a [serious game] flow of actions" (Arnab et al., 2015, p. 396). To provide an example for future designers, I have included a map we used for conceptualizing the flow of mechanics in *Chroniclers*. See Figure 9. This map represents each level's structure within *Chroniclers*. Such a map has aided the initial design phase by providing a point of consistency.

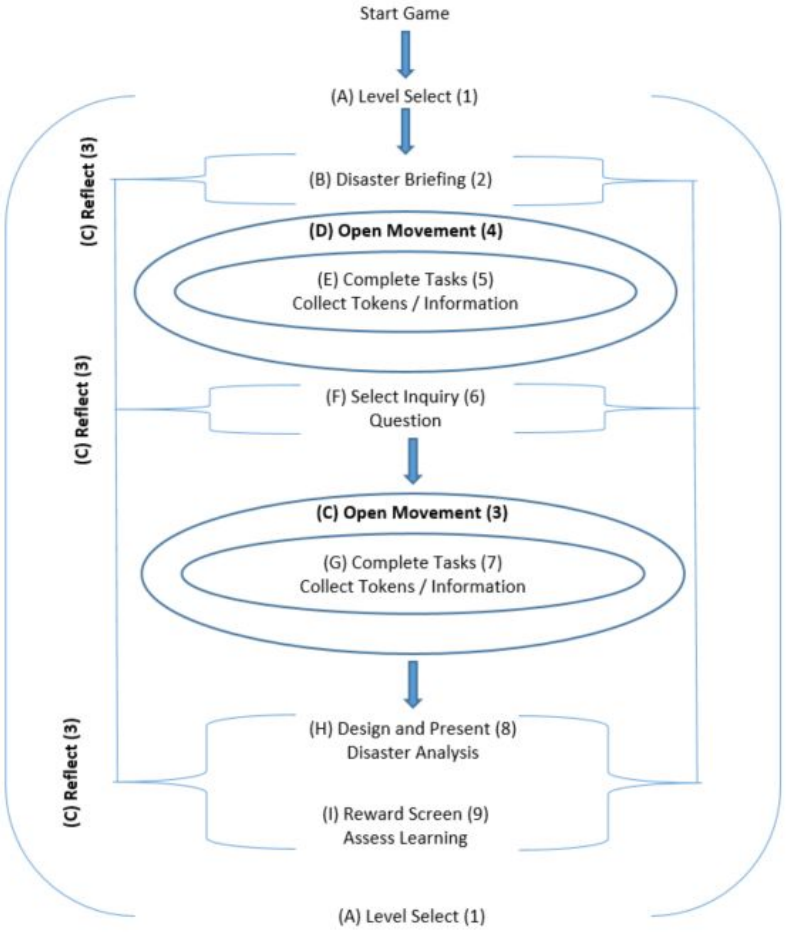

Figure 10: Conceptual map presenting the dynamic appearance of game mechanics through each level of The Chroniclers.

In order to push the state of information literacy games beyond declarative knowledge tasks, other game designers benefit from the three general steps presented here. Furthermore, by determining which game mechanics to include at the initial phases of game design, differing stakeholders (developers and designers, as well as collaborating librarians and classroom teachers) will have a common language and structure to refer to throughout the design process.

Discussion

As digital games are increasingly adopted for information literacy instruction, future designers may benefit from this investigation of games recently created in the field. This scoping literature review revealed 12 papers from 2013–2018 that described the creation or

adaptation of nine games for information literacy instruction. These papers varied in their level of detail regarding their learning objectives and the in-game mechanics to reach those intended goals. Although the identified papers generally described positive user evaluations and some promising learning outcomes, the review revealed that information literacy game designers continue to depend on scavenger hunt-style game mechanics and transcribing declarative learning tasks to digital environments.

Based on these findings, I have outlined three general steps future designers may utilize for creating information literacy games. Specifically, I suggest (1) framing the game within a specific information literacy model, (2) including student reflection and performance-based information literacy tasks, and (3) connecting game mechanics with learning mechanics. In order to provide an example of these steps, I have relayed our conceptualization process for *The Chroniclers.*

Certainly, game development is costly, and interested parties must consider the return on investment for such endeavors. The need for greater evidence of information literacy game effectiveness, a deficit noted by Markey, Leeder, and Reih (2014), still exists. Although learning games may show promise, future designers should avoid investing resources into games that simply support knowledge acquisition (Boyle et al., 2016). By pinpointing in-game actions that support skill acquisition and then analyzing their effectiveness, future parties may determine that game-based learning will support their information literacy learning objectives.

Limitations

The mechanics outlined in *Chroniclers* have not yet been fully developed or tested through user evaluations. As development proceeds, such steps will be necessary to ensure

students are reaching targeted learning outcomes. The hope is that our design process will ensure that we test the right game mechanics when we reach this phase of development.

I also recognize that interested parties may not have the financial or technical resources readily available to realize their subsequent game concepts after following the design recommendations. Upon following these recommendations, however, future teams might ensure that resources are efficiently allocated to meet student learning goals rather than unnecessary in-game mechanics.

Lastly, the review's use of the term "information literacy" may have skewed the number of identified papers. Although information literacy is a cross-curricular skill and often considered the umbrella term for other literacies, it is possible that there are papers covering similar topics but did not use this term or "research skills" within their abstracts, opting instead for a term such as "critical thinking skills."

Conclusion

Game-based learning continues to intrigue researchers and practitioners alike. Previous literature reviews (Smale, 2011; Broussard, 2012) have provided insight into the ways in which games are being designed and used for information literacy instruction. This scoping review builds upon that research in order to examine the most current state of digital games for information literacy education. The results of this review illustrate that, although game-based information literacy instruction studies indicate positive results, these games largely continue to rely on learning mechanics that are limited to declarative learning tasks. In order to push games to support higher-order learning outcomes, future designers may benefit from greater inclusion of literacy models and performance-based tasks supported by linking game mechanics to

learning mechanics. Incorporating these recommendations, future designers may advance the state of the field.

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Appendix A

Example Design Document for *The Chroniclers*

<table>
<tr><td colspan="3">Mesopotamia
Topics: Agricultural revolution, social class structure of Mesopotamia, code of law</td></tr>
<tr><td colspan="3">Social Studies Objective
Explain how the geography, economics, government, advancements, and beliefs affect the culture of ancient Mesopotamia.</td></tr>
<tr><td colspan="3">Level Structure</td></tr>
<tr><td colspan="3">Part 1: Open</td></tr>
<tr><td>Learning Mechanic</td><td>Game Mechanic</td><td>Implementation</td></tr>
<tr><td>– Discover</td><td>– Cut Scene/Story
– Levels</td><td>– Screen to select ancient civilization
– Cut scene explains story/region</td></tr>
<tr><td colspan="3">Description:
Within their in-game, personalized workstation at Historian’s Universal Base (HUB), player chooses where to search for Soter. Player exits HUB screen followed by cut scene. Galileo describes the chaos Soter has caused in Mesopotamia.</td></tr>
<tr><td colspan="3">Part 2: Immerse</td></tr>
<tr><td>Learning Mechanic</td><td>Game Mechanic</td><td>Implementation</td></tr>
<tr><td>– Explore</td><td>– Questions & Answers
– Reflect/Discuss</td><td>– On-rails player movement with Galileo
– Dialog tree</td></tr>
<tr><td colspan="3">Description:
Galileo leads the player through city, highlighting the achievements of Mesopotamia. As Galileo guides player, dialog tree mechanic appears. Tree gives the player questions to ask regarding the chaos Soter has created.</td></tr>
<tr><td colspan="3">Part 3: Explore</td></tr>
<tr><td>Learning Mechanic</td><td>Game Mechanic</td><td>Implementation</td></tr>
</table>

– Explore – Action/ Task	– Selecting/Collecting – Movement – Tokens	– Freedom of movement – Navigational map with points of interest icons (POIs) – Player journal and task tokens
Description: Player is now free to explore the roam the havoc. Navigational map is unlocked, populated with POIs from Galileo's tour. Based on (but not limited to) POIs, player investigates artifacts and speaks with non-player characters, completing tasks (e.g., constructing canals, establishing cuneiform, etc.). These tasks reveal details on specific challenges facing the community. Non-player characters reward player with tokens and supplemental information regarding the challenge. Information and tokens are logged within player, in-game journal.		
Part 4: *Identify*		
Learning Mechanic	*Game Mechanic*	*Implementation*
– Reflect /Discuss – Identify	– Feedback – Strategy/ Planning	– Visualization of in-game data: exploration, tasks, etc. – Galileo guides reflection
Description: After completing designated number of tasks, player returns to the HUB. Galileo presents player with data regarding his exploration, showing trends in his task interests and anomalies discovered during their exploration. This process ends with Galileo guiding the player through reflective questions. Galileo then provides player with potential inquiry questions to research (e.g., "How can we ensure the population has a grain surplus?"). Player is given time to pause, consider, review their journal, and ultimately choose his specific mission.		
Part 5: *Gather*		
Learning Mechanic	*Game Mechanic*	*Implementation*
– Action/Task – Generalization /Discrimination – Analyze	– Goods/Information – Tokens – Reflect/Discuss	– New environment based on inquiry question is now accessible to the player – Specific zones of environment contain content related to chosen inquiry

Description:
Based on the player's chosen question, a new part of the environment is accessible. Having completed tasks in each zone ("going broad"), the player now "goes deep."

If their inquiry task is related to surplus grain, for example, a zone could be related to constructing canals, another zone is related to the invention of the plow, etc. Upon completing tasks in this specific zone, player is rewarded with information tokens. Galileo helps player evaluate the information they have unlocked (e.g., how the Fertile Crescent relates to agriculture).

Additionally, interface prompts the player to complete a journal entry (using an in-game text entry box). In this entry, player must reflect on what keywords they will use to find more information on the phenomenon.

Part 6: *Create*

Learning Mechanic	*Game Mechanic*	*Implementation*
– Observation – Demonstrate – Analyze	– Selecting/Collecting – Goods/Information – Design/Editing	– Extensive database searches – Infographic construction – Instructions from Galileo

Description:
After completing designated number of tasks in the new inquiry zone, the player returns to the HUB to begin database searches. The searches should be informed by their gameplay experience and chosen tokens.

This research is done in-game using a pre-programmed database. Galileo guides the player through constructing a Boolean search strings for this database. The player then conducts searches on his own, selecting information to help answer his research question.

Once the player indicates that he has gathered enough data, Galileo reappears. It instructs the player to choose an infographic template in which to write their answers. In this template, the player also places the tokens they earned by completing tasks in Mesopotamia.

Part 7: *Share*

Learning Mechanic	*Game Mechanic*	*Implementation*
– Ownership – Participation	– Ownership – Competition – Cooperation	– Student work uploads to 3D room that houses peer work

Description:
Upon finishing their infographic, an image of this graphic is uploaded to the HUB Command Center. The Center houses all other player infographics. Players may then view other students' research.

Part 8: *Evaluate*		
Learning Mechanic	*Game Mechanic*	*Implementation*
– Feedback – Repetition – Reflect/Discuss	– Levels – Cut Scene/Story – Status	– Screen presents statistics, accomplishments, and evaluation prompt
Description: After submitting their infographic in the Command Center, a cut scene describes and displays the player's accomplishments. Galileo rewards player badges and a new title based on their performance/ancient scenario. Lastly, Galileo asks player to evaluate their learning experience via Likert-scale questions. Text-entry then appears, asking the student to reflect on the process. Player selects next ancient world to experience.		