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COOKIEMANIA: EXPLORING THE APPLICATION OF INQUIRY-BASED LEARNING WITHIN DIGITAL LITERACY GAMES

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Abstract

CookieMania: Exploring the Application of Inquiry-Based Learning Within Digital Literacy Games

by

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During this information age, video games have been utilized as a medium to teach individuals about digital literacy. Games that teach digital literacy in this thesis are defined as games that delve into the topics of computer programming, digital citizenship, big data and cyber-security, ethical consequences of tech, and learning specialized skills in this digital age. While there has been many organizational analysis on how games teach other important social topics, there has been little analysis on organizing the teaching methods of the different types of digital literacy games available today. I analyzed and organized 28 video games that are tagged under the umbrella term of digital literacy. Using Thematic Analysis, I analyzed each game's learning mechanics (Choice, Minigames, Scripted Events, Exploration, Non-Interactive) and mapped it into an inquiry-based teaching approach (Confirmatory, Structured, Guided, and Open/True). Once I finished this synthesis I applied it in a digital literacy game I developed called, CookieMania, and describe how each learning mechanic has been implemented to follow this thematic analysis.

Chapter 1

Introduction and Literature Review

1.0.1 Digital Literacy

Digital literacy can be considered an umbrella term that combines multiple literacy's of visual, media, collaborative, and mass information [60, 68, 41]. In this information age, access to information from new digital sources has revolutionized the way individuals learn and explore topics [41]. Students have new educational games and mediums where they can explore and discover how to be a digital citizen [59, 17]. However, this transformation has also introduced novel problems and risks such as the rapid spread of misinformation, cyber-bullying, polarization, and more [68, 41, 56, 49]. With the onset of COVID-19 and the rise of misinformation online, it is even more important that people become aware of how mass digital information works. It isn't a surprise that there has new research and attempts to try and educate individuals through digital literacy classes, seminars, and more [49, 35]. This has become a common occurrence to integrate the which these gains and pains into the normal curriculum of

students [4, 68]. While these mediums have been explored greatly in research, one popular teaching medium that is growing in traction is teaching digital literacy with video games, and more specifically, serious games.

1.0.2 Serious Games

Serious games have existed existed throughout history in all shapes and forms. A serious game is simply a game that's designed for purposes other than pure entertainment [30]. These games are designed with the pure intent of teaching their subject matter rather than pure entertainment. Even though entertainment is a primary motivator for a player to engage and learn in a game, the foundation of a serious game is that this is directly tied with how the game is developed [64]. However, serious games still follow the same limitations of variability, with the amount of work that could be placed in it extremely vast [30, 64, 14]. These games can exist both in the physical and virtual world, from board games to video games. With current times, serious games are now tied more to video games, which is the focus of this thesis. Educational games are a subset of serious games, where their main intention is to teach and inform people through playing their game [30, 53, 48]. These types of games are great tools for learning as in addition to normal teaching [30, 14, 25]. When analyzing these games for learning, it's important to note that there is always a distinction between the main and learning mechanics.

1.0.3 Learning Game Mechanics or Teaching Methodology

When viewing games as a teaching tool, rather than entertainment, there has already been plenty of work that helps define what it means to teach through a video game [40, 30, 14, 25]. The crux of this world highlights that there is a clear distinction between a *game's primary mechanic*, which is the primary way a player engages with the game. The *learning mechanic*, the gameplay mechanic where the teaching subject is delivered [1, 7, 45]. This distinction is important as our main ability to assess a game's teaching efficacy is through directly analyzing how they teach information [1]. A helpful example would be a data-security game DATAK, where players work for a simulated company and help manage their customer's data [50]. In this game, the primary game mechanics are clickable environments and short minigames similar to temple-run, where a player runs on a path to gain resources. The main learning mechanic, or the method they teach big data and data security, comes from displaying readable texts or making choices in moral dilemmas. This difference of mechanics is an important distinction as the teaching method is evaluated when analyzing serious games [1, 30, 62, 29]. Once this distinction is clarified, then we can go deeper into the method of how do these games act as teachers.

1.0.4 Learning through inquiry

Analysis in education is similar to how you can break apart the teaching method within these games. As a more interactive tool, these games can also be seen as teachers, as they typically provide an individual-assisted experience for the players

to learn something new [30]. One theoretical framework of how to approach analyzing the more profound methodology of how this game teaches is how does it make a player think or inquire [67, 53]. In education, inquiry learning is a theory based on a constructivist approach, which means that students have to create the knowledge in their head rather than passively taking it [53, 67, 44]. While there are different schools of thought for how a student learns, games typically follow a self-learning environment where they generally are not tested or assessed to the same degree as learning in school [2, 62]. In this inquiry-based approach, it comes to the expectation that learning is not transferred from teacher to student. Instead, the student has to use the information provided to create their learning [39, 37]. This type of learning is a spectrum of different types, based on inquiry or teachable moments. These four designated types are as described below: Confirmation Inquiry, Structured Inquiry, Guided Inquiry, and Open/True Inquiry [67].

1.0.5 Confirmation Inquiry

This type of inquiry built into lessons requires the highest teaching involvement, as well as the most passive student engagement [67]. In this process, the teacher provides all the information and answers on the learning outcomes, and students typically have to reinforce what they have learned either through reading or applied for work, or read work tasked by the teacher [67, 20, 6]. This standard approach of teaching allows the teacher to have full control of all subject matter and the process of how a student is expected to learn [20]. This path requires low student engagement in understanding the topic but can be more easily be tested and checked on whether the desired

conclusions are retained, and recalled [31]. This passive method of learning is common, and its aim is to reinforce and repeat important information [39, 2].

1.0.6 Structured Inquiry

Structured inquiry requires teachers to create and set expectations and processes for the subject. This inquiry type involves a moderate amount of involvement for the teacher as the teacher guides and instructs each student for what they need to learn [44]. This would help set up the teaching plan within this path, where they would be required to think or expand on what they have learned. The student would follow set processes and be mostly taking part in the learning through a passive but typically linearly built lesson plan [67, 31].

The emphasis within structured inquiry is that it is the most linear path that naturally leads into clear set boundaries of how to start a research question, how to find evidence, and then creating a satisfactory solution based on that evidence [67]. This process is typically seen as a reliable and consistent method of teaching as it provides the teacher with enough control to set and develop expected outcomes within a single lesson plan [2, 31]. However, while this process is well used, it doesn't fully capture the complete research process of discovering self-made observations and conclusions, nuances and exceptional cases, and exploring different paths and outcomes [67, 53, 31]

1.0.7 Guided Inquiry

In the guided Inquiry approach, typically, the teacher only provides the research question of the expected learning outcomes. The students decide what they should do when solving this research topic with minimal guidance from the teacher. In this scenario, the craft of making these expandable and robust research problems are the crux of the teacher's involvement, and they rely on the students to create the finalized conclusions from this guided inquiry [67].

Guided inquiry takes a step beyond the linear process of structured inquiry. With guided inquiry, since the conclusions are not pre-determined and expected, it provides students with higher retention, and overall understanding of the subject matter [51, 39, 37]. This inquiry type also has a downside as higher degrees of uncertainty make it harder to assess the full efficacy of this inquiry-based method[67, 44, 13]. Also, suppose the student does not have sufficient initial foundational knowledge. In that case, the process of learning becomes extremely difficult as there is not as much support that could come from the teacher [6].

1.0.8 Open/True Inquiry

In the Open/True Inquiry, students have a topic to explore mostly by themselves. The teacher will provide them access to these informational resources, but it is primarily up to the student to discover more about said topic [51]. The breadth of work of the student can significantly vary in this case as there is no standardized approach or path for the student to follow; the teacher only provides them with the base tools to

start this open and true inquiry [31]. This leads to the higher levels of retention for a subject matter but can suffer if students do not have basic support or motivation for work [67, 5].

The greatest strength that comes from open and true inquiry is that it is the most flexible when it comes to a student's approach to answer a question [5, 32]. This type of learning has the closest relationship to research and experimental work done by scientists and requires a higher order of thinking [67, 5, 32]. This method does not just create a single learner but instead is a learning community from both the teachers and students [67]. While this provides the most significant amount of learning, it also requires an incredible amount of participation and involvement from the student [31]. This is incredibly hard to navigate and implement as the teacher has to perfectly balance open inquiry and perfectly crafted questions with the students' motivation. There is no easy standard path for a teacher to follow this learning type and no easier way to normalize assessments [13].

1.0.9 Lack of Research

The reason why we dive deep into these teacher-student theories is that in many serious games papers, the video game is typically seen as an assistant teacher or tool [45, 58]. It is an addition to an already built curriculum, and in some cases, people want it to be a sufficient enough replacement for teaching topics [40, 30]. Understanding how a game implements these learning mechanics and applying this educational framework in educational games. There have been many studies that show how to design more

effective serious games that use supported teaching theories as well as to implement them into games correctly [1, 7, 29, 64, 58, 37]. While there are a lot of papers that study how the integration methods of teaching theories in these games, there is a significant lack of foundational research when it comes to understanding the teaching methodology of digital literacy games

There have been many games that have been analyzed for their teaching theory, from games to teach topics in STEM. For example, when looking at an analysis of the mapping between learning and game mechanics within games, the games these scholars analyzed typically were involved in educational settings in STEM, and not more soft skills such as understanding digital landscapes [30, 1]. When narrowing the analysis of learning mechanics and teaching insights into the scope of digital literacy games, it was almost non-existent. Only a few works dive deep into the learning mechanics of games in sub-categories of digital literacy such as misinformation/data information to cybersecurity games [25, 35, 56, 49]. A few web-based games are sponsored by non-profits or schools that try to create small-scale games to teach digital literacy to kids [54, 59]. Still, they follow the same route of never being analyzed; however, to get a deeper understanding of whether or not mapping these learning mechanics is done the same way for this game topic, we have to start with a stronger foundation of how digital literacy games teach.

1.0.10 Goal of Paper

This thesis will develop a starting point at analyzing these games for their learning outcomes and mechanics. I will be conducting a thematic analysis to survey inquiry-based teaching methodologies in current digital literacy games. We will describe this methodology in the following chapter. This process will start from the beginning of searching and cataloging 28 games that are under this digital literacy umbrella. For each game, we diligently analyzed its contents. We organized it to create a foundation to understand what these games teach, how these learning mechanics teach digital literacy topics, and how they act as teachers. We will map them onto constructivist inquiry-based learning theory to help showcase that digital literacy games follow similar teaching trends as other games. As the current landscape is still unexplored, this is the first step to understand to what extent are these standards and methodologies tracking onto digital literacy games.

Once I developed the initial synthesis, I applied it to a serious game I developed called CookieMania. This game follows the essential principles of design. We optimize learning mechanics by integrating them into the game mechanics of minigames, moral choices, scripted events, exploration, and passive and non-interactive learning. Using these game mechanics as a framework, I synthesized my survey of inquiry-based teaching methodologies to develop this game. I will describe how each learning mechanic in my game represents these four significant types of inquiry. Due to Covid-19, we never completed a final test for the game's efficacy. We will discuss future goals and

implications in our conclusion.

Chapter 2

Methods

Before beginning the thematic analysis, I developed an initial plan for our query for digital literacy games. This can be seen in Figure One. These steps ensure that each game has been treated to the same rigor of analysis before conducting any research.

2.0.1 Step 1 Defining Search Parameters

The first step of this process is to identify our initial search parameters. Once Digital Literacy was defined, we used this information to create our key search parameters for finding these games. Using keywords of digital literacy video games, tech literacy video games, social media video games, I developed a sense of what these games could look like. They could range from web-based coding game independently developed games or high-budgeted triple a games.

2.0.2 Step 2 Searching Through Databases

The second step after this exploratory phase was to conduct a search in more formal database settings. Mainly using known locations of games databases, I queried the databases of gamesforchange.org, gamesdatabase.org, steam.powered.com, and google to search for games that had similar keywords as defined in the previous section. We can find the number of games found from each database in TABLE 1. The gamesforchage, gamesdatabase, and steampowered.com searches contained filter tools that allowed me to narrow the search for digital literacy games. Once I found a potential match, I double-checked on Wikipedia and other stores to confirm the legitimacy and consistency of the information provided for the games. To find more possible games not captured by the database, I also did a query on Google to find relevant games with the exact keywords. A total of 28 games were collected and the amount found from each are database is collected. Once I found enough matches that fit our criteria, I started analyzing individual games

2.0.3 Step 3 Content Analysis Part 1 Categorizing Digital Literacy Subject

The next step was categorizing

2.0.4 Step 4 Content Analysis Part 2 Categorizing Learning Mechanic

Before synthesizing the process into thematic analysis, the final step was to conduct a content analysis of each game cataloged. For this base analysis, I measured the

fun and learning mechanics, how to access the game, the subject of digital literacy, and general information such as the date created. To analyze game mechanics, I observed the trailer and gameplay videos on YouTube on what the player would have to do to progress or finish the game. In terms of learning mechanics, while I was observing the digital literacy game, I noted how the game presented the teaching or inquiry information. Whether it was shown as part of the story and text or done through an exploration of the world, I kept track of how these games presented the relevant information tied to their digital literacy subject. I marked down the main learning mechanics they utilized for each game and did that for each game. Figure 2 provides an example of how I organized details. Once this data was collected, I started the thematic analysis and surveyed how these learning mechanics looked like inquiry-based learning theory.

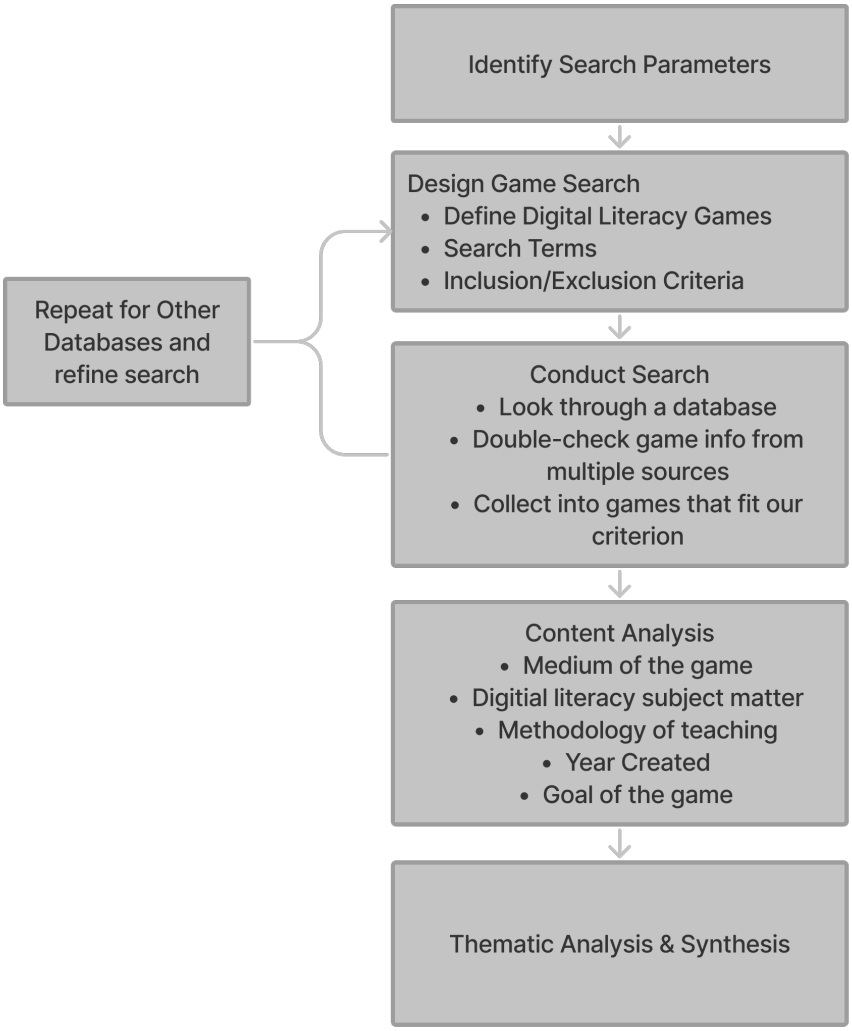

Figure 2.1: Step by step by step process of how the search for games began. We started by defining our search parameters into locating them in various databases, and then doing a thorough analysis and catalogue of their contents.

Name of Database	# of Games
gamesforchange.org	16
Steam	7
gamesdatabase.org	3
Google	2

Figure 2.2: These were the digital literacy topics each subject focused on. The numbers are as follows: Programming (n=5) [54, 36, 11, 12], Big Data/Cybersecurity [50, 43, 18, 14, 3, 9] (n=6), Online Citizenship (n=7) [24, 17, 59, 42, 16, 19, 3], Broader Skills (n=4) [55, 22, 23, 21], Ethical Issues (n=7) [66, 61, 16, 63, 28, 12, 10]

Games	Programming	Big Data/CyberSecurity	Online Citizenship	Broader Skills	Ethical Issues
Codecademy	✓				
Erase All Kittens	✓				
While True: Learn()	✓				
The Foos	✓				
Datak		✓			
Data Dealers		✓			
Facticious		✓			
CookieMania		✓			
Interland Web			✓		
Digital Compass			✓		
The Carnegie Cyber Academy			✓		
CyberBully Zombie Attack			✓		
Factorio				✓	
Machineers				✓	
Breaking-Boundaries in Science				✓	
Detroit Become Human					✓
Eliza					✓
Fake it to Make it					✓
Gedbadnews					✓
Troll Factory					✓
Icivics games					✓
Human Resource Machine	✓				
Autonauts				✓	
GetBadNews			✓		
Tacoma			✓		
Ireporter BBC		✓	✓		
Crowds					✓
We Become What we Behold		✓			

Figure 2.3: These were the digital literacy topics each subject focused on. The numbers are as follows: Programming (n=5), Big Data/Cybersecurity (n=6), Online Citizenship (n=7), Broader Skills (n=4), Ethical Issues (n=7).

Chapter 3

Thematic Analysis

3.0.1 Learning Mechanics

Thematic analysis is the primarily used methodology of mainly using qualitative data collected through more extensive data sets to identify patterns and meanings across them [65, 33]. In this thesis, thematic analysis collects data from 28 digital literacy games and analyzes their contents to visualize trends in inquiry-based learning. I look at a game's core learning mechanics used to teach digital literacy for their respective subjects by treating these games as teachers.

First, I dived deeper into understanding how each game delivered its learning outcomes through the Thematic Analysis. I analyzed and categorized their gameplay and learning mechanics and organized it to how their game is supposed to teach the desired digital literacy topic. This is important to do as a game's primary mechanic may not be how a user is supposed to learn from the game. For example, in Factitious, a game that users swipe right or left to whether a news article is fake or not, the primary

game mechanic is swiping left or right[18, 25]. Its learning mechanic shows the player their score and results and explains how each one is fake or real. For each game, I observed youtube gameplay for at least 20 minutes that would span from beginning, middle, and end to find out their main teaching methods. Once I made these notations and understood primary teaching methods in games, I categorized them into these five main teaching methodologies. [8]

It is important to note that these games can contain more than one of these five teaching methodologies. Each of these five teaching methods can also be in a spectrum. This means that there are different degrees of utilization of the methods. For example, some games use moral dilemmas as small events in the game, while others use it as their entire gameplay mechanic.

3.0.2 Non-interactive Learning

Non-interactive learning is related to teaching methods within games that rely on expected memorization of content with no extra reinforcement in learning. Very similar to techniques in passive learning [48]. This type of learning would be the lowest level of learning a player of face as it doesn't help reinforce or guide players deeper into the digital literacy topic. An example game would be CyberBully Zombie Attack which initial claim was to teach its players about situations regarding cyberbullying [42]. However, when you play the game, it is only an imitation of another popular game, Plants vs. Zombies, with monster and character models transformed technology like computers or enemies like malware. There is no expansive story, and the game only

utilizes these models to represent the desired learning outcome of cyberbullying.

3.0.3 Minigames

Minigames are popular methods of integrating learning outcomes in video games, especially within the realm of serious and educational games [64]. However, their efficacy is still up to debate as most minigames only serve to progress the game, with their gameplay mechanics not always directly related to the actual subject matter. For example, in the cybersecurity/bigdata game, Datak, players are tasked with managing a company that's in charge of handling its consumer's data [50]. After the player goes through its premise and the initial moral dilemma, they make money to progress the game by playing a skating minigame to avoid possible malware. This method suffers from a similar process of non-interactive teaching through minigames as only the models represent the subject matter. However, the game provides extra details of the goals and how these models represent real-world data. With this in mind, some minigames are created with the learning outcome in mind in the forefront, meaning that the minigame serves to teach the player something new about the topic. In CookieMania, a similar topic game, one minigame players play is to play a space shooter game where the player protects their data from pirates and malware [14]. The pirates and malware's behaviors represent how they would act in real life, allowing mapping learning outcomes to the minigame's design rather than just a model change.

3.0.4 Scripted Events

Learning through scripted events occurs when a player learns the digital literacy subject through set events or story beats. The most common implementation of scripted events is through the dialogue of the game or whenever a player faces an event in which they have to learn something new about the subject. An example of this would be back to CookieMania, which has both minigames and scripted events [14]. When a player encounters a new enemy in any minigames, the player provides an on-screen dialogue prompt that tells the player what type of internet cookie this monster represents and its behavior. As they progress through the story, the player will also experience pre-built events that move the story forward and outline a future learning outcome, such as digital privacy laws. These scripted events are one of the more popular methods of teaching in games as it provides clear guidelines of when information of the subject creates a sense of progression and build-up that aids the learning process [30, 1]. Another example of scripted events would be the game Interland. In this game, players go through game islands that contain different learning outcomes surrounding digital citizenship [17]. Players go through scripted or pre-determined social scenarios regarding each data topic. They are only allowed to pass through the next level if they answer correctly, or to say, reached a conclusion desired by the game.

3.0.5 Choice

The implementation of interactive narrative or the ability for the user to make impactful choices through games has shown to be a beneficial tactic at engaging the

user and increasing a player's retention of information [14, 40, 39]. Examples of these are when players are required to make choices on moral dilemmas, choose from a set of different actions, or make decisions on paths of solving problems. These can range from low-impact methods of integrating multiple-choice quizzes to the more interactive aim of story-driven activities. Detroit Become Human is an example of a game that utilized this as the primary learning mechanic. In this game, you take control of multiple characters, robot or human, through a primarily interactive narrative that explores the nuances and ethics of robotic and digital evolution [15]. Through most of the game, players have to make decisions regarding many social dilemmas and actions, such as deciding whether to save a robot from destruction and maltreatment or save a human. These games heavily focus on engaging the user's emotions and showing them the consequences of their action, allowing them to learn the subject on a more personal level. In another example, the web game Get Bad News makes players face moral dilemmas of whether they want to send out fake news to get more points or provide accurate information and get no traction [16].

3.0.6 Exploration

Exploration learning has the broadest breadth of learning mechanics but is typically the path that allows the player to choose what they have to learn, interact with the world and environment, and set their own pace up for learning. Most games have some degree of exploration, such as the ability for the player to interact with the world environment to learn more about either a specific character or story. However,

some games are built on pure exploration, with the teaching made through a player's curiosities. One game that fully utilizes this structure is Breaking-Boundaries in Science, which is a VR game where players get to explore the labs and offices of great female scientists [23]. In this game, players walk around an interactive room where they learn more about its history and significance once they interact with an object. A player can skip most learning outcomes entirely, but the user has the most significant control in deciding what they want to learn and how to approach learning in this environment.

3.0.7 Mapping into Inquiry based Learning

Once these games were categorized and synthesized, it was time to map these mechanics into our Inquiry-based learning approaches to understand further how they act as digital literacy teachers. Once we set the game as a teacher's representative, we can view the game's learning mechanics as teaching methods. We can apply our inquiry-based learning theories and map each learning mechanic to each type of inquiry by doing this.

3.0.8 Confirmation Inquiry

I mapped confirmation inquiry to two different types of learning mechanics: Non-interactive learning and Minigames. The description of confirmation inquiry suggests that the teacher would have the highest involvement in developing the learning outcome and its presentation. This parallel would mean that the teacher already makes most of the inquiry, and in this case, the game. In non-interactive learning mechanics,

low engagement occurs when the player reads walls of text or is just given information with barely any context [29, 1, 62]. In this situation, the game or teacher expects the inquiry process to reaffirm the lessons or expect a low amount of player inquiry. Minigames also follow this trend where most minigames reinforce the information they might have learned throughout the game. For example, in the match Factitious, the primary mechanic of the minigame is to swipe left or right on whether you think an article is fake or not. It immediately responds and is utilized as a method to reinforce the learning of the game, which are paragraphs that pops up after a player swipes [25]. While minigames vary significantly in how they are implemented as a learning mechanic due to their variable nature, they are usually utilized as a confirmatory tool with not a lot of inquiry expected during the minigame process.

3.0.9 Structured Inquiry

I mapped scripted events to structured inquiry due to its ability to develop linear paths of delivering the learning outcome. The teacher, or game in this case, is typically expected to create a guide or path for the player to follow. The game sets and makes the moments in which inquiry is available in scripted events, either through provided pre-planned events or storylines. Players learn from the game under specific circumstances and set those guidelines..

3.0.10 Guided Inquiry

I mapped choice-based learning mechanics into the guided inquiry as thinking about choices is similar to simply posing a research question. Guided inquiry requires the teacher to provide only the research question and then expect the student to think about their possible discovery options. When games implement choices, especially moral dilemmas, the player receives a problem, or similarly, a research question. It is entirely up to them to make that critical choice and learn from the consequences of their action. The game never tells them which option is correct, only how their actions affect the game's world. In Detroit Become Human, an interactive choice-based game about robot ethics and more, the player has the option to go back and see how their decisions affected multiple story branches. This example illustrates how these games can provide players the context and tools needed to see every possibility and consequence.

3.0.11 Open/True Inquiry

Finally, exploration is the most intuitive mapping into open/true inquiry. In open/true inquiry, students have the tools to explore a subject without specific instructions. There are few but still very impactful games that cherish a non-linear storyline and provide the players a mostly unlimited landscape to explore. In the VR game, Breaking-Boundaries in Science, players explore offices of significant female figures throughout history. There is no test or quiz to assess their learning; instead, it simply provides them with the tools and environment to develop their own open and proper inquiries.

With these learning mechanics finally mapped into inquiry-based learning, I then applied this foundational knowledge to my own digital literacy game, CookieMania [14].

Games	Choice	Minigames	Scripted Events	Exploration	Non-Interactive Teaching
Codecademy			✓		✓
Erase All Kittens		✓	✓	✓	
While True: Learn()			✓	✓	
The Foos		✓	✓		
Datak	✓	✓	✓	✓	
Data Dealers			✓	✓	
Facticious	✓			✓	
CookieMania	✓	✓	✓	✓	
Interland Web	✓	✓	✓	✓	
Digital Compass	✓		✓	✓	
The Carnegie Cyber Academy		✓			✓
CyberBully Zombie Attack					✓
Factorio		✓	✓	✓	
Machineers		✓	✓		
Breaking-Boundaries in Science				✓	✓
Detroit Become Human	✓		✓	✓	
Eliza	✓	✓	✓	✓	
Fake it to Make it	✓		✓		
Gedbadnews	✓		✓		
Troll Factory	✓		✓	✓	
Icivics games			✓		
Human Resource Machine		✓	✓		
Autonauts			✓	✓	
GetBadNews			✓	✓	
Tacoma	✓		✓	✓	
Ireporter BBC	✓		✓		
Crowds	✓		✓		
We Become What we Behold	✓		✓		

Figure 3.1: These were the 28 games analyzed for the thematic analysis and the primary learning mechanics found in every game. The number of games that use each learning mechanic are as follows: Choice (n=14) [50, 18, 14, 24, 17, 15, 66, 61, 16, 63, 19, 3, 10, 9], Minigames (n=10) [52, 11, 50, 14, 24, 59, 55, 66, 12, 22], Scripted Events (n=24) [54, 52, 36, 11, 50, 43, 14, 24, 17, 55, 15, 66, 12, 21, 61, 16, 63, 28, 21, 16, 19, 3, 10, 9, 22], Exploration (n=16) [52, 36, 18, 50, 43, 14, 24, 17, 55, 23, 15, 66, 21, 63, 21, 16, 19], Non-interactive Teaching [54, 59, 42, 23]

Games	Confirmation Inquiry	Structured Inquiry	Guided Inquiry	Open/True Inquiry
Codecademy	✓	✓		
Erase All Kittens		✓		✓
While True: Learn()		✓		✓
The Foos		✓		
Datak	✓		✓	✓
Data Dealers		✓		✓
Facticious			✓	
CookieMania	✓	✓	✓	✓
Interland Web	✓	✓	✓	✓
Digital Compass		✓		✓
The Carnegie Cyber Academy	✓			
CyberBully Zombie Attack	✓			
Factorio	✓	✓		✓
Machineers	✓	✓		
Breaking-Boundaries in Science	✓			✓
Detroit Become Human		✓	✓	✓
Eliza	✓	✓	✓	✓
Fake it to Make it		✓	✓	
Gedbadnews		✓	✓	
Troll Factory		✓	✓	✓
Icivics games		✓		
Human Resource Machine	✓	✓		
Autonauts		✓		✓
GetBadNews		✓		✓
Tacoma		✓	✓	✓
Ireporter BBC		✓	✓	
Crowds		✓	✓	
We Become What we Behold		✓	✓	

Figure 3.2: These were the 28 games analyzed for the thematic analysis and the primary inquiry-based teaching methods mapped from learning mechanics.A majority of games utilized Structured inquiry (n=23) [54, 52, 36, 11, 50, 43, 14, 24, 17, 55, 22, 15, 66, 12, 21, 61, 16, 63, 28, 21, 16, 19, 3, 10, 9], and others used confirmation inquiry (n=11)[52, 11, 50, 14, 24, 59, 55, 22, 66, 12, 54], open/true inquiry(n=15) [52, 36, 18, 50, 43, 14, 24, 17, 55, 23, 15, 66, 21, 63, 21, 16, 19],, and guided inquiry (n=13) [50, 18, 14, 24, 17, 15, 66, 61, 16, 63, 19, 3, 10, 9]

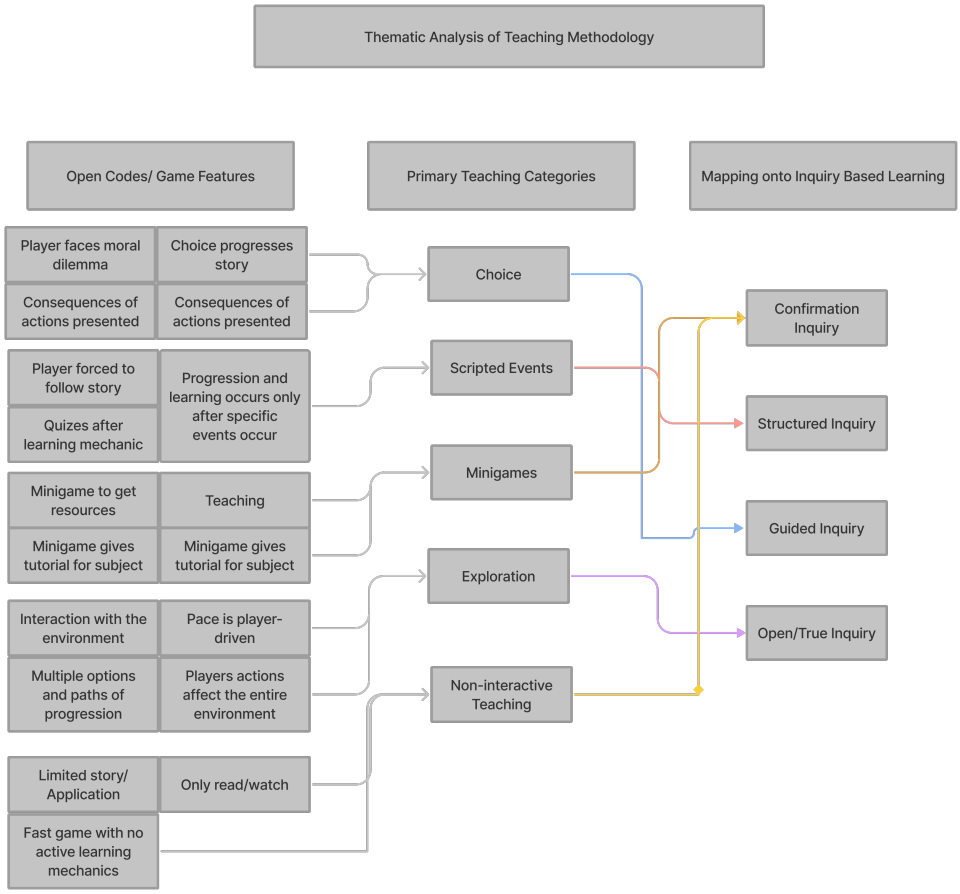

Figure 3.3: We started the thematic analysis by first categorizing the trends in learning mechanics within the games. Once we set and created the five primary learning mechanics, we then mapped them into inquiry-based teaching approaches to see what were the favored type of methods.

Chapter 4

Application: CookieMania

We developed Cookie Mania to focus not only on teaching players what internet cookies are, but also how internet cookies are affecting their very lives. We do this through a linear 5-month storyline in which players become a website manager for a major technology company. Throughout gameplay, players are introduced to several major NPC characters which they can interact with through dialogue choices. Their interactions with these NPCs contain both teaching moments and moral decisions that mirror ethical issues which have arisen in the real world. In between the segments of interactive narrative, learners will also play cookie-based minigames designed to further increase player engagement and motivation. These minigames act as set mile-stones throughout the narrative and are necessary to move the story forward.

4.0.1 Gameplay and Learning Outcomes

Based on the many ethical issues surrounding internet cookies as well as their current applications and relevance, we determined 5 key learning outcomes that were critical for players to learn through gameplay. Since the game covers a timeline of five months, we have ordered these learning outcomes by the in-game month they are taught to the player. These month-by-month progressions also allow us to make the storyline more fluid, making the jumps between learning each outcome coherent within the story line. For example, by the time the player reaches to the final month where they learn how to protect themselves and others with data consent, they would have experienced a data breach, viruses, different types of cookies used by companies, and general knowledge of how cookies are used in their everyday lives. The learning outcomes are as follows [14]: (MONTH 1) Understand the definition of internet cookies and the different types of cookies that are implemented within websites. (MONTH 2) Reinforce cookie knowledge by using real world context and scenarios including laws and large events related to the topic. (MONTH 3) Help players understand how companies use different types of cookies and how they work internally through basic lessons on ML, AI, and marketing. (MONTH 4) Teach players how cookies are related to virus and malware spread, as well as how to prevent it. (MONTH 5) Provide players with real world actions and guidance for how to act regarding sharing information to cookies and consenting to it.

4.0.2 Mapping Learning Mechanics to Inquiry Based Learning

From the start, we wanted to make sure we captured every single type of learning based as our original goal was to iterate and evaluate these the efficacy of these mechanics. We developed an interactive game where we attempted to make the game the teacher. With this goal in mind, we made sure that when we developed our goals for inquiry-based learning, we mapped out our learning mechanics and gameplay to fit that theoretical mode. In this game, players experience the four different inquiry-based learning.

4.0.3 Confirmation Inquiry

To improve and add upon our original learning mechanics, we developed a non-interacting teaching method through the upgrade system. Once players' finish the minigames, they will have points that they have accumulated to spend on upgrades. The way we implemented confirmation inquiry was by having each upgrade containing details about cyber security and how it works. Throughout the game we teach these topics, but the upgrades simply reinforce their learning.

We also added personalization for a player's character and their website. While no teaching goals were set for character customization, we attempted make the customizability of the website and company to represent how different companies build their market. The reason it is confirmation is that we do not highlight these choices throughout the story, and is typically a background detail we expect the user to take note sometimes.

4.0.4 Structured Inquiry

The majority of this game actually involves minigames. They were made to provide extrinsic motivation to play the game, and can be chosen through the Desktop scene (SEE FIGURE). Most of the progression of Cookie Mania lies with playing minigames multiple times, collecting points for upgrades and unlocking to the next month. Currently, there are two minigames that can be played, the marketing minigame and the security minigame. In the marketing minigame, the player is instructed to jump to different platforms to avoid malicious cookies and collect good ones for the company. In the security minigame, the player is instructed to protect their customer's data by destroying viruses and zombie cookies from reaching the data. For both of these games, to highlight structured inquiry, we made sure that whenever a new monster is introduced, it was related to one of the learning outcomes, and their gameplay was similar to this detail. For example, for our Lag Cookie, we made it function so it slowed down players to showcase its. This next table also showcases s the different types of cookies taught in the game and their distinctive visual representations.

4.0.5 Guided Inquiry

When we go to guided inquiry, a major component that we have in the game are Moral Choices. We set up two scenes, office and desktop, where a majority of players will read and experience moral dilemmas regarding their company's data, and are expected to make moral decisions that affect their reputation meter. These choices affected the endings, but more importantly they demonstrate the consequences of their actions for

both the consumer and provided. This showcases how we simply guided the player to the situation, but it was ultimately up to them to decided on their own thoughts and inquiries about the topic. We also made sure that the events and moral choices within the game mirrored events that occurred in real life in the U.S.. We focused on different scandals from big tech companies. Specifically we tackeld their problems with internet cookies and recommendation algorithms. For example, Cambridge Analytica was a major scandal in the United States where Facebook user's data were taken without consent by Cambridge Analytica, causing major discussions on privacy and user rights [27]. Using this event, we implemented a storyline within the game that mimicked the events of Cambridge Analytica, with moral decision making and repercussions for whether to include consent at the player's company.

4.0.6 Open/True Inquiry

Finally, we wanted to make sure the the process for players to explore was integrated within this game to some capacity. While this is the hardest one to create and manage, we believe we were able to caputure open/true inquiry through our analytics Page. The analytics page provides players with a growing knowledge set of how cookies work and what they provide in the "website manager" context. The screen visually shows how many websites use these cookies and what information they collect. They provide a constant stream of interactive information for the player to explore and discover how their actions are affecting a larger subset of information such as website traffic, popularity, and more. These stats are affected by their options, but they hold no

importance for they play through the game. It's simply a method of exploring deeper into how data is collected in the game that mimics real life.

The final but simple method of exploration was our email tab. This is a hub that provides narrative related information and keeps track of a players moral decision making, similar to Detroit Become Human. Players can use this tab to replay tutorials, reread specific events and dialogue, or explore additional information on what they are learning in that month. They are also provided with real-world resources to learn and education themselves about these important topics.

Chapter 5

Discussion

The first goal of this thesis conducts a thematic analysis to survey inquiry-based learning with digital literacy games. Then using that knowledge, I wanted to apply what I learned from that survey into developing a serious game that would directly apply all four types of inquiry-based learning most accurately for analysis. That is how my game development team and I developed CookieMania, a serious game to teach internet cookies. We made sure the inquiries mapped into our learning mechanics in this game.

When going through the starting point of thematic analysis, which was to do database searches, there was a severe lack of resources to find digital literacy games. As the topic is vast, there were a lot of options of how to categorize and pick games that were directly related to the topic. Even with the game databases, since digital literacy has only been a more prominent topic in this new millennia, so too are the breadth of what is considered games.

When it came to the thematic analysis, the survey of how inquiry-based learning was mapped onto learning mechanics was a difficult task. Due to the nature of each different type of learning mechanics having their paradigms, it's almost impossible to capture them into one specific type of inquiry-based learning fully. Minigames are notorious for having extreme freedom of exploration and self-guided paths, to simply being a side distraction with only reading and passive learning [64, 1]. However, when the learning mechanic is fully described and designed with these inquiry-based learning theories as to its foundation, it becomes a lot easier to develop it in my game, CookieMania [14].

As a first-time game developer, when I started the recruitment process of my game development team, I didn't fully understand the enormous scope required to develop a serious game. Designing a game to teach requires a lot of preparation, from setting learning outcomes to deciding how we want to teach these essential topics [1, 7, 30]. We developed a storyboard, ideas for learning mechanics backed by research and created an alpha demo of our game through a collaborative process.

The first key finding from when I initially did my analysis is that as there are multiple methods of teaching the digital literacy subject, the same also applies within games. Primary learning mechanics can appear in many factors of the game, which is especially true when we view a game as having multiple teaching methods. When I initially did the survey of learning mechanics to inquiry-based learning, I attempted to limit a game to only acting as one type of inquiry-based learning. However, as we developed and designed the many learning mechanics of CookieMania, it was apparent

that every kind of inquiry-based learning needs to be within each game.

When we designed our learning mechanics with the foundational knowledge of inquiry-based learning, it was easier to create minigames and processes that better captured it into the four inquiry-based learning categories. By having a firm notion of how CookieMania is a teacher and how we could use it as a medium to showcase and engage players with all the different types of inquiries, the process of developing a serious game with educational theory was smoother. When I compared it to games such as Datak, the most similar digital literacy game as CookieMania, I noticed that their design did not fully capture all four types of inquiries [50]. If a serious game design approach was integrated with this inquiry-based learning to develop digital literacy games, it would be easier to teach and evaluate them. Inquiry-based games and self-learning games have been showing to help students retain and process subjects better [2, 58, 62]. And in more recent years, a digital literacy game has been tested and shown to help confer psychological resistance to fake news [68].

Chapter 6

Limitations and Future Directions

When it came to the data collection, there were several exclusion criteria that we first developed but eventually weakened due to the lack of digital literacy games available. These relaxed criteria were: genre of game, duration of the game, subject of the game, and year. Game genre is a vast world, ranging from the well-known first-person shooter games to purely narrative-based games. The genre has a significant impact on how a player engages with fun and what they expect from it [49, 30, 29]. The games I analyzed were from an extensive breadth of games, but a lot ended up being story-based, leading to a possible bias or trend that maybe digital literacy games are designed for the story.

Duration of the game was also another important topic as some games could range from an average playtime of five minutes to thousands of hours. This time factor means that the game's learning mechanics design could depend on the regular playtime, as a developer would not build in massive moral choices and impactful stories if the

game runs extremely short.

It was tough to find many games specific to each digital literacy topic when it came to the more basic game information, like the subject of game and year. For example, most coding-based games were web-based or kid games with entirely different game mechanics and audiences. Many of the games also came from similar years, which makes sense as this topic is extremely recent in the gaming world, leading to exciting games of similar issues coming out in the same year. Finally, a majority of games found were primarily played on the PC, as the information age has primarily driven the evolution and boom of computers and information tools [60]. Where people access, games change the design and application of many learning mechanics, as they might have different controls or realm of possible implementations [30].

In regards to CookieMania, when we started the development of CookieMania, we went into it to conduct User Research and studies to assess the efficacy of the game. However, due to COVID-19, the ability to user test the possible learning from these games fruition. I would want to directly assess and survey each implemented learning mechanic in the future. This next step could be done either through full playthroughs or stratified testing of each learning mechanic and see how it made the user engaged, retain information, and most importantly, learn and enjoy the game. Our team was also small and could not reach the full completion of the game as people graduated or had to leave due to different obligations.

Chapter 7

Conclusion

We attempted a grand vision of integrating inquiry-based learning theory into learning mechanics in the game, CookieMania. While we never assessed the true efficacy of how this application could improve learning outcomes, a thematic analysis to survey this inquiry-based learning theory was created. There is now initial work detailing the inquiry-based teaching approaches of the current digital literacy game landscape and an application for how these approaches could look like in a serious game. While many gaps and problems still occur in the data collection process due to the limited scope and breadth of these types of games, this synthesis and application was a necessary step in understanding how digital literacy games teach and how they could be applied to new technologies serious games.

Bibliography

[1] Sylvester Arnab, Theodore Lim, Maira B. Carvalho, Francesco Bellotti, Sara de Freitas, Sandy Louchart, Neil Suttie, Riccardo Berta, and Alessandro De Gloria. Mapping learning and game mechanics for serious games analysis. *British Journal of Educational Technology*, 46(2):391–411, 2015.

[2] Bada and Steve Olusegun. Constructivism learning theory : A paradigm for teaching and learning. 2015.

[3] BBC. Ireporter bbc. PC, 2020.

[4] Vladlena Benson and Alsa Kolsaker. Instructor approaches to blended management learning : a tale of two business schools. 2015.

[5] C. Anders R. Berg, V. Christina B. Bergendahl, Bruno Lundberg, and Lena Tibell. Benefiting from an open-ended experiment? a comparison of attitudes to, and outcomes of, an expository versus an open-inquiry version of the same experiment. *International Journal of Science Education*, 25(3):351–372, 2003.

[6] Margaret R. Blanchard, Sherry A. Southerland, Jason W. Osborne, Victor Samp-

son, Leonard A. Annetta, and Ellen M. Granger. Is inquiry possible in light of accountability?: A quantitative comparison of the relative effectiveness of guided inquiry and verification laboratory instruction. *Science Education*, 94:577–616, 2010.

[7] Michael Callaghan, Maggi Savin-Baden, Niall McShane, and Augusto Gómez Eguíluz. Mapping learning and game mechanics for serious games analysis in engineering education. *IEEE Transactions on Emerging Topics in Computing*, 5(1):77–83, 2017.

[8] Janelynn Camingue, Edward F. Melcer, and Elin Carstensdottir. A (visual) novel route to learning: A taxonomy of teaching strategies in visual novels. 2020.

[9] Nicky Case. We become what we behold. PC, 2016.

[10] Nicky Case. The wisdom and/or madness of crowds. PC, 2018.

[11] codeSpark. The foos. PC, 2014.

[12] Tomorrow Corporation. Human resource machine. PC, 2015.

[13] National Research Council. Inquiry and the national science education standards: A guide for teaching and learning. 2000.

[14] John Dominic Diez and Edward Melcer. Cookie mania: A serious game for teaching internet cookies to high school and college students. pages 69–77, 10 2020.

[15] Quantic Dream. Detroit become human. PC, 2018.

[16] DROG. Fake it to make it. PC, 2017.

[17] Common Sense Education. Digital compass. PC, 2003.

[18] Maggie Farley and Bob Hone. Datak. PC and mobile, 2018.

[19] Fullbright. Tacoma. PC, 2017.

[20] Erin Furtak and Alicia Alonzo. The role of content in inquiry-based elementary science lessons: An analysis of teacher beliefs and enactment. *Research in Science Education*, 40:425–449, 05 2009.

[21] Curve Games. Autonauts. PC, 2019.

[22] Lohika Games. Machineers. PC, 2014.

[23] Lohika Games. Breaking boundaries in science. VR, 2018.

[24] Google. Interland web. PC, 2017.

[25] Lindsay Grace and Bob Hone. Factitious. *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*, 2019.

[26] Lindsay D. Grace and Peter Jamieson. Gaming with purpose: Heuristic understanding of ubiquitous game development and design for human computation. *Handbook of Digital Games*, page 645–666, 2014.

[27] Margaret Hu. Cambridge analytica's black box. *Big Data & Society*, 7(2):2053951720938091, 2020.

[28] iCivics. icivics games. PC, 2009.

[29] Yasmin Kafai, M.L. Franke, Cynthia Ching, and J.C. Shih. Game design as an interactive learning environment for fostering students' and teachers' mathematical inquiry. *International Journal of Computers for Mathematical Learning*, 3:149–184, 05 1998.

[30] Kijpokin Kasemsap. Mastering educational computer games, educational video games, and serious games in the digital age. *Advances in Game-Based Learning Gamification-Based E-Learning Strategies for Computer Programming Education*, page 30–52, 2017.

[31] Alla Keselman. Supporting inquiry learning by promoting normative understanding of multivariate causality. *Journal of Research in Science Teaching*, 40:898 – 921, 11 2003.

[32] Rebecca Krystyniak and Henry Heikkinen. Analysis of verbal interactions during an extended, open-inquiry general chemistry laboratory investigation. *Journal of Research in Science Teaching*, 44:1160 – 1186, 10 2007.

[33] Petros Lameras, Sylvester Arnab, Ian Dunwell, Craig Stewart, Samantha Clarke, and Panagiotis Petridis. Essential features of serious games design in higher education: Linking learning attributes to game mechanics. *British Journal of Educational Technology*, 48(4):972–994, 2016.

[34] Alexis Le Compte, David Elizondo, and Tim Watson. A renewed approach to serious games for cyber security. pages 203–216, 2015.

[35] Ioana Literat, Yoo Kyung Chang, and Shu-Yi Hsu. Gamifying fake news: Engaging youth in the participatory design of news literacy games. *Convergence: The International Journal of Research into New Media Technologies*, 26(3):503–516, 2020.

[36] Luden.io. while true: learn(). PC and Mobile, 2017.

[37] Julie A. Luft. Changing inquiry practices and beliefs: The impact of an inquiry-based professional development programme on beginning and experienced secondary science teachers. *International Journal of Science Education*, 23(5):517–534, 2001.

[38] Sana Maqsood and Sonia Chiasson. Design, development, and evaluation of a cybersecurity, privacy, and digital literacy game for tweens. *ACM Trans. Priv. Secur.*, 24(4), sep 2021.

[39] David A. McConnell, LeeAnna Chapman, C. Douglas Czajka, Jason P. Jones, Katherine D. Ryker, and Jennifer Wiggen. Instructional utility and learning efficacy of common active learning strategies. *Journal of Geoscience Education*, 65(4):604–625, 2017.

[40] Edward Melcer and Katherine Isbister. Bridging the physical learning divides: A design framework for embodied learning games and simulations. 08 2016.

[41] David Cooper Moore. Bringing the world to school: Integrating news and media literacy in elementary classrooms.

[42] NetSmartz. Cyberbully zombie attack. PC, 2013.

[43] Cuteacute Media OG. Data dealer. PC, 2013.

[44] Margus Pedaste, Mario Mäeots, Leo A. Siiman, Ton de Jong, Siswa A.N. van Riesen, Ellen T. Kamp, Constantinos C. Manoli, Zacharias C. Zacharia, and Eleftheria Tsourlidaki. Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, 14:47–61, 2015.

[45] Jan Plass, Bruce Homer, Charles Kinzer, Jonathan Frye, and Ken Perlin.

[46] Iulian Radu and Bertrand Schneider. What can we learn from augmented reality (ar)? pages 1–12, 05 2019.

[47] Pritika Reddy, Kaylash Chaudhary, Bibhya Sharma, and Darren Chand. Contextualized game-based intervention for digital literacy for the pacific islands. *Education and Information Technologies*, 26:1–28, 09 2021.

[48] Jacqueline M. Ritzko and Sherry Robinson. Using games to increase active learning. *Journal of College Teaching Learning (TLC)*, 3(6), 2011.

[49] Jon Roozenbeek and Sander van der Linden. Fake news game confers psychological resistance against online misinformation. *Palgrave Communications*, 5(1), Jun 2019.

[50] RTS and DNA Studios. Datak. PC, 2017.

[51] Irit Sadeh and Michal Zion. The development of dynamic inquiry performances within an open inquiry setting: A comparison to guided inquiry setting. *Journal of Research in Science Teaching*, 46:1137–1160, 2009.

[52] Dee Saigal and Leonie Van Der Linde. Erase all kittens. PC, 2017.

[53] Kimberly Sheridan, Kevin Clark Clark, and Erin Peters. How scientific inquiry emerges from game design, March 2009.

[54] Zach Sims and Ryan Bubinski. Codecademy. PC, 2011.

[55] Wube Software. Factorio. PC, 2020.

[56] Eugenio Tacchini, Gabriele Ballarin, Marco L. Della Vedova, Stefano Moret, and Luca de Alfaro. Some like it hoax: Automated fake news detection in social networks, Apr 2017.

[57] A. Terracina, R. Berta, F. Bordini, R. Damilano, and M. Mecella. Teaching stem through a role-playing serious game and intelligent pedagogical agents. pages 148–152, 2016.

[58] Weimin Toh and David Kirschner. Self-directed learning in video games, affordances and pedagogical implications for teaching and learning. *Computers Education*, 154:103912, 2020.

[59] Carnegie Mellon University. Carnegie cyber academy. PC, 2007.

[60] Graham Walton. “digital literacy” (dl): Establishing the boundaries and identifying the partners. *New Review of Academic Librarianship*, 22(1):1–4, 2016.

[61] Amanda Warner. Fake it to make it. PC, 2017.

[62] Wen-Hsiung Wu, Wen-Bin Chiou, Hao-Yun Kao, Chung-Hsing Alex Hu, and Sih-Han Huang. Re-exploring game-assisted learning research: The perspective of learning theoretical bases. *Computers Education*, 59(4):1153–1161, 2012.

[63] Yle. Troll factory. PC and Mobile, 2019.

[64] Zhonggen Yu. A meta-analysis of use of serious games in education over a decade. *International Journal of Computer Games Technology*, 2019:1–8, 02 2019.

[65] Zarwina Yusoff, Amirrudin Kamsin, Shahab Band, and A. Chronopoulos. A survey of educational games as interaction design tools for affective learning: Thematic analysis taxonomy. *Education and Information Technologies*, pages 1–26, 01 2018.

[66] Zachtronics. Eliza. PC, 2019.

[67] Michal Zion and Ruthy Mendelovici. Moving from structured to open inquiry: Challenges and limits. *Science education international*, 23:383–399, 2012.

[68] Şenol Mail Pala and Adem Başıbüyük. The predictive effect of digital literacy, self-control and motivation on the academic achievement in the science, technology and society learning area. *Technology, Knowledge and Learning*, 2021.