AALTO UNIVERSITY
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Understanding Digital Information Literacy Games

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Disinformation is a threat to a democratic society. Disinformation refers to deliberately misleading information that leads to disagreements and makes it difficult to assess the reliability of information. This bachelor's thesis examines learning games that teach Digital Information Literacy (DIL). DIL refers to the ability to critically evaluate media texts and distinguish useful fact-based information from disinformation. Studies have shown that learning games can be used to develop DIL and thus combat disinformation. Learning games have been found to be more effective than traditional teaching methods, but current research remains limited.

This work is conducted in the form of a literature review. The aim of the thesis is to present the current state of the field of DIL games, identify research gaps, raise potential new research questions, and provide guidelines for developers of DIL games. The goal is for this work to serve as a starting point for new developers and researchers in the field of DIL games.

The objective is pursued by examining four key areas related to DIL games: DIL teaching and assessment, the concept of games, research on published DIL games, and the analysis of educational games. In each of these areas, an existing study on the topic is reviewed and compared to other sources. The scope of this work is limited to discussing one research study for each topic, as it is not feasible to conduct an exhaustive literature review on all four subjects. The work does not comprehensively cover all aspects of DIL but focuses on examining it from the perspective of disinformation.

This thesis provides guidelines for developing DIL games based on the review, lists existing DIL games and studies conducted on them, and suggests methods for selecting the appropriate research tools for evaluating learning games. The research found that developing DIL games requires a multidisciplinary team, including designers, teachers, researchers, and artists. The work recommends that developers of DIL games familiarize themselves with the concept of DIL, features of games, previous games, and tools for game analysis.

The research revealed deficiencies in interactivity in DIL education. While teachers can teach critical reading, they often lack an understanding of concepts such as cookies and social media algorithms. Furthermore, it was found that DIL-enhancing learning games help protect players from disinformation, but their impact is short-lived. A significant limitation is that research related to DIL games often focuses on very similar methods and targets young adults. Future research should expand this approach with new methods and population segments. Additionally, the number of conducted studies and their sample sizes are small, necessitating more comprehensive research to determine the true effectiveness of learning games.

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Keywords: disinformation, digital information literacy, media literacy, learning games, framework

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Disinformaatio on uhka demokraattiselle yhteiskunnalle. Disinformaatio tarkoittaa tarkoituksellisesti harhaanjohtavaa tietoa, joka johtaa erimielisyyksiin ja vaikeuttaa tiedon luotettavuuden arviointia. Tässä kandidaatintyössä tutkitaan digitaalisen median lukutaitoa kehittäviä oppimispelejä. Digilukutaidolla tarkoitetaan kykyä arvioida mediatekstejä kriittisesti ja erottaa hyödyllinen faktapohjainen tieto disinformaatiosta. Tutkimuksissa on havaittu, että oppimispelejä voidaan käyttää digilukutaidon kehittämiseen ja siten taistella disinformaatiota vastaan. Oppimispelien on havaittu toimivan perinteisiä opetusmenetelmiä paremmin, mutta tutkimustietoa on toistaiseksi vähäisesti.

Työ on toteutettu kirjallisuustutkimuksen muodossa. Työ pyrkii esittämään digilukutaitopelien alan nykytilanteen, nostamaan esiin puutteita tutkimuksissa ja avaamaan mahdollisia uusia tutkimuskysymyksiä sekä esittämään ohjeita digilukutaitopelien kehittäjille. Tavoitteena on, että työ toimii hyvänä aloituspisteenä digilukutaitopelien kehittäjille ja tutkijoille.

Tavoitteeseen on pyritty pääsemään tarkastelemalla neljää digilukutaitopeleihin liittyvää osa-aluetta: digilukutaidon opetusta ja arviointia, pelin käsitettä, julkaistujen digilukutaitopelien tutkimusta sekä opetuspelien analysointia. Jokaisessa osa-alueessa tarkastellaan olemassa olevaa kirjallisuustutkimusta aiheesta ja verrataan sitä muihin lähteisiin. Työ on rajattu käsittelemään yhtä tutkimusta jokaisesta aiheesta, sillä työ ei pysty toteuttamaan kattavaa kirjallisuustutkimusta kaikista neljästä aiheesta. Työ ei pysty kattavasti käsittelemään digilukutaidon kaikkia osa-alueita, joten se keskittyy tarkastelemaan digilukutaitoa disinformaation näkökulmasta.

Työssä esitetään ohjeita digilukutaitopelien kehittämiseen tutkimukseen pohjautuen, lista olemassa olevia digilukutaitopelejä ja niistä tehtyjä tutkimuksia sekä menetelmä oikeanlaisten tutkimustyökalujen valintaan oppimispelejä arvioitaessa. Työllä saatiin selville, että digilukutaitopelien kehittämiseen vaaditaan monialainen työryhmä, joka sisältää suunnittelijoita, opettajia, tutkijoita sekä taiteilijoita. Työssä suositellaan digilukutaitopelien kehittäjiä tutustumaan digilukutaidon käsitteeseen, pelien ominaisuuksiin, aikaisempiin peleihin sekä työkaluihin pelien analysointiin.

Työllä saatiin selville, että digilukutaidon opetuksessa on puutteita interaktiivisuuden osalta. Opettajat osaavat opettaa kriittistä lukemista, mutta heiltä puuttuu ymmärrystä esimerkiksi evästeistä ja sosiaalisen median algoritmeista. Lisäksi työllä saatiin selville, että digilukutaitoa kehittävät oppimispelit auttavat suojaamaan pelaajia disinformaatiolta, mutta vaikutuksen kesto on lyhyt. Merkittäväksi puutteeksi selvisi, että digilukutaitopeleihin liittyvät tutkimukset keskittyvät usein hyvin samankaltaisiin menetelmiin ja kohdistuvat nuoriin aikuisiin. Tulevien tutkimusten kannattaisi laajentaa tätä lähestymistapaa uusilla menetelmillä ja väestönosilla. Lisäksi tehtyjen tutkimuksien määrä ja otannat ovat pieniä, joten tarvitaan kattavampia tutkimuksia selvittämään oppimispelien todellinen toimivuus.

Työn ohjaaja: Vesa Kantola
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Asiasanat: disinformaatio, digilukutaito, medialukutaito, oppimispelit, työkalu, pelit

PREFACE

I want to thank Vesa Kantola for taking interest in my game design path and introducing me to the field of disinformation. I also want to thank Mikko Salo and the crew of Faktabaari, the University of Washington's Center for an Informed Public and Loki's Loop (lookisloop.org) team for helping me dive deeper into the topic of disinformation and games.

Otaniemi, Finland, September 2023

Hiski Huovila

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1 Introduction

1.1 Overview

Disinformation is a growing epidemic worldwide (Albright, 2017) as false information spreads quickly over the internet. Disinformation threatens democracy by creating disagreements on facts and doubt in the credibility of information (Wikforss, 2023). This threat can be mitigated by targeting youth with proper digital information literacy (DIL) education (Scheibenzuber and Nistor, 2019). Teachers can teach general media literacy but lack some of the necessary knowledge and tools to teach more complex or interactive aspects of the online world (Cherner and Curry, 2019). That interactivity can be captured with games, which Roozenbeek and Van Der Linden (2019b) suggest as possible solutions against misinformation. Many such games have been created, such as *The fake news game* (Roozenbeek and Van Der Linden, 2019b) but there is a lack of knowledge about research on games in DIL education. This lack of understanding creates issues with teachers who might be distrustful of games as educational tools. Similarly, a lack of knowledge on games in DIL game research results in suboptimal DIL games.

1.2 Goals and research questions

This thesis aims to create an understanding of DIL games by providing an overview of digital information literacy and its evaluation, and an overview of games followed by a discussion on DIL games and their evaluation using the following research questions:

1. How should DIL be approached in education?
2. What qualities do educational games have?
3. What game-related solutions are used for DIL education?
4. How are DIL games evaluated?

Based on these questions this thesis aims to provide concrete guidelines for creating DIL games, and to be a thorough starting point of information for DIL game developers and researchers. This thesis provides a short introduction to DIL games from the disinformation point of view and a review of research conducted on different DIL games and frameworks used to evaluate educational games.

Chapter 2 forms a basic understanding of digital information literacy, the state of its teaching and concludes with recommendations on how DIL should be taught and measured. Chapter 3 focuses on understanding what a game is and what advantages

games bring to education. Chapter 4 continues with a discussion and review of DIL games and the results of DIL game studies. Finally, chapter 5 presents how educational games can be evaluated and how researchers can select an appropriate framework for modeling these games followed by a conclusion and recommendations in Chapter 6.

1.3 Limitations

1. This thesis does not contain empirical research. Therefore, it can only provide pre-existing solutions to problems.
2. This thesis cannot comprehensively compare existing DIL game research projects or game evaluation tools. Therefore, this thesis uses pre-existing literature reviews as the basis for its arguments.
3. Digital Information Literacy is a large field. This thesis will focus on disinformation and critical reading as the main topic of DIL. Consequently, the solutions discussed in this thesis might not be suitable for other aspects of DIL.

2 Teaching Digital Information Literacy

Digital Information Literacy (DIL) is a complex topic with many definitions. Different sources might describe DIL with different names, such as Digital Information Fluency (DIF) or critical reading in a digital context. It could be argued that critical reading is a subsection of DIL or that high level of DIL results in DIF. This thesis refers to this phenomenon as DIL using the following definitions:

> *[Digital information literacy is the] ability to obtain, understand, evaluate, and use information in a variety of digital technology contexts.* (Sparks, Katz and Beile, 2016).

> *Digital Information Fluency (DIF) is the ability to find, evaluate and use digital information effectively, efficiently and ethically. DIF involves Internet search skills that start with understanding how digital information is different from print information, knowing how to use specialized tools for finding digital information and strengthening the dispositions needed in the digital information environment.* (Heine and O'Connor, no date).

> *With critical reading skills, we refer to the ability to critically read and evaluate the credibility of different kinds of texts (including multimodal texts) – this means that critical reading goes well beyond basic reading skills (word decoding and literal comprehension). (Kiili, Siuko and Ninaus, 2023).*

Someone with high digital information literacy can understand and use digital online platforms safely. One major aspect of DIL is the ability to understand and evaluate the credibility and validity of information. Hence, understanding disinformation is a vital part of DIL. This thesis uses disinformation and anti-disinformation education as the lens through which DIL is observed.

2.1 Disinformation

Disinformation is information created to be intentionally misleading (Fallis, 2015). Some definitions of information might not accept the concept of misinformation as information (Fallis, 2015) but for this thesis, information is defined as "...something that represents some part of the world as being a certain way", which includes disinformation (Floridi, 2012; Scarantino and Piccinini, 2010; cited by Fallis, 2015).

Disinformation is misinformation, meaning it is misleading - information likely to create false beliefs. If a piece of information is not likely to create false beliefs even if it is factually false, it is not considered misinformation. (Fallis, 2015)

Disinformation differs from misinformation in that it is intentionally misleading. Information created in error or hard-to-understand satire is not considered disinformation (Fallis, 2015). Information that is factually true but intentionally used to inflict harm is called malinformation (Carmi *et al.*, 2020).

2.2 State of DIL education

Media literacy is already a part of many curriculums. In many cases, teachers are free to interpret and teach media literacy in ways they find appropriate. Consequently, the abilities of a teacher regarding the field of DIL are directly related to how comprehensively their students will learn about DIL.

Cherner and Curry (2019) studied how pre-service teachers from Moyer Pacific University's College of Education are prepared to teach media literacy education. Many of them emphasized critical analysis of media messages in their teaching. The analysis was focused either on the contents of the message itself or the creator and receiver of that message.

Participants were confident in their ability to teach both analyzing and creating messages but were less confident in their understanding of media technology or media copyright laws. Importantly, participants were not confident in their understanding of misinformation. Participants were least confident in their ability to teach how to engage in online discussions and debates and reported a low understanding of targeting technologies such as cookies or social media algorithms. (Cherner and Curry, 2019)

Games have unique advantages to teach these more interactive aspects of the online world. The advantages of games in education are discussed in Chapters 3, 4 and 6. The following section focuses on improving DIL education and evaluation with a discussion of the DIL games context.

2.3 Improving DIL evaluation and education

To effectively measure the impact of DIL solutions DIL needs to be properly measured and evaluated. Numerous tools have been created for different purposes to measure and define DIL. A literature review of DIL evaluation tools by Sparks, Katz and Beile

(2016) is used as a basis for understanding how best to approach DIL in game development.

2.2.1 Defining DIL

DIL is an evolving and difficult-to-define construct. Sparks, Katz and Beile (2016) found two approaches for defining DIL for evaluation: picking a framework that defines DIL in concrete objectives or describing DIL only in high-level concepts and letting evaluators measure DIL holistically.

Some educators prefer a concrete and subdivided definition that allows them to split the topic of DIL into smaller subsections that can be taught and evaluated individually. This more granular approach allows for individual tailoring of DIL education for each student based on their performance in different areas. (Sparks, Katz and Beile, 2016)

That approach, however, fails to teach the big picture of DIL. As DIL is a large and multi-faceted construct, a holistic approach where the subject is seen only as high-level concepts will better capture the full outlook of DIL. One way to better achieve high-level understanding is to use scenario-based teaching which is discussed in the following Section. (Sparks, Katz and Beile, 2016)

2.2.2 Scenarios and relevant context

According to Sparks, Katz and Beile (2016), DIL evaluation should in most cases be based on real-world scenarios. Different contexts should have the evaluation tailored to the types of interactions that happen in that context. Students should focus on school-related scenarios, professionals should focus on workplace-related scenarios, and so on. Due to rapid technology change, DIL scenarios might become obsolete quickly and evaluators should review their scenarios periodically to ensure they remain relevant. (Sparks, Katz and Beile, 2016)

Is scenario based learning effective? When comparing argument-based and scenario-based learning, Aslan (2019) found no major difference in results but both methods were more impactful than traditional learning. He found that student engagement is the driving factor in effective learning, which scenario-based learning can provide.

When evaluating and teaching DIL, the context should be tailored to be engaging and relevant for the people being evaluated both for evaluation quality and improved learning.

Sparks, Katz and Beile (2016) argue that while technological skills in DIL education are important, cognitive mechanisms behind those skills should be given priority. According to them, real-life scenarios are a good way to measure cognitive skills in technology contexts. The role of technological skills is discussed in the following Section.

2.2.3 Avoid specifics

Because DIL is not necessarily dependent on specific technologies, technological literacy should not be required in DIL evaluation. Any evaluation tasks and questionnaires should be completable with general knowledge of common digital tools. This way, competency in specific tools will not affect the assessment of DIL skills. (Sparks, Katz and Beile, 2016)

Linguistic proficiency in technology-related jargon helps students when learning DIL skills. Students who learn "the language of the internet" are better able to ask for help when operating online and also formulate an understanding of the issues they face. (Jeffrey *et al.*, 2011)

Consequently, when assessing and teaching DIL, hyper-specific language should be avoided. Basic online jargon should be considered part of being digitally literate and thus included in DIL education.

Even though technology should be minimized when teaching DIL, technology can be used to efficiently automate parts of the process. This automation is discussed in the following Section.

2.2.4 Automation and reporting

Modern technology is sufficient enough to automate the scoring of tasks beyond multiple-choice questionnaires. Large-scale evaluation of DIL by using trained human evaluators is not feasible for many institutions. Therefore, while non-optimal, automated scoring is sufficient. (Sparks, Katz and Beile, 2016)

According to Sparks, Katz, and Beile (2016) the optimal score reporting method for DIL assessment would provide large-scale data for the institutions conducting the study while also providing granular feedback for the individual being assessed. Institutions need proper knowledge of the procedures to assess whether DIL goals have been met and individuals benefit from knowing which aspects of DIL they are lacking or succeeding in.

With the recent advances in large language models (LLMs), AI-based evaluation tools for large written assignments could soon become sufficient for evaluating and teaching basic DIL skills. AI tools can be used to analyze sentiment in online messages and for content moderation as demonstrated by Davidson *et al.* (2017). Some recent tools are also used to detect and fact-check articles online (Graves, 2018).

3 What is a game?

Games are slowly emerging as an alternative to traditional teaching methods. Research widely suggests that games are effective learning tools, even surpassing traditional methods and when paired with traditional face-to-face teaching, results improve even further (de Freitas, 2018).

Many definitions for games have been proposed and there is no perfect definition to explain what a game is. For this thesis, *game* is defined as "a problem-solving activity, approached with a playful attitude" as defined by Jesse Schell (2015). However, besides an exact definition of the term, what is more important are the characteristics found in many definitions of *game*. This chapter contains a discussion on *10 topics of interest among game definitions* by Jaakko Stenros (2017) together with 10 qualities of *game* by Jesse Schell (2015) with a discussion of the DIL context.

3.1 Games have rules

Stenros (2017) notes that most definitions for games mention rules though the definition of rules remains vague. Some definitions omit rules and instead offer *choice* as the alternative. Stenros references Sid Meier as "a game is a series of interesting choices" (Rollings and Morris, 2004). Schell (2015) concurs with Stenros' findings: games differ from toys in that they have rules that need to be followed.

Rules and choice should be part of the definition of a DIL game as well. What differentiates a game from other forms of DIL education is interactivity within a rules framework. A ruleless interaction could be, for example, a discussion and a choiceless rule set could be a reading assignment. A game should allow students to choose while retaining integrity and rules.

3.2 Purpose, function, and usefulness

While usually not explicitly stated, Stenros (2017) finds that many definitions of *game* ascribe it with purpose. Stenrose attributes to Ståhl (1983) five functions for games. These are *entertainment games, educational games, experimental games, research games,* and *operational games*. From these, DIL games fall into the category of educational games, though Becker and Parker (2014) propose that a good fit for learning game development is a middle ground between entertainment and educational content.

That middle ground has to be threaded properly. *Edufication* happens when game designers reskin an existing game with some educational content leaving the learning aspect lacking (Becker, 2008; cited by Becker and Parker, 2014). The reverse can also happen: In *edutainment*, educators take educational material and try to turn it into a game without proper design, which results in games that are not engaging at all (Van Eck, 2011; cited by Becker and Parker, 2014).

Schell's (2015) game designer perspective agrees: *games can create internal value*. The purpose of a game is to entertain. One major aspect that Schell notes that seems to apply to all games is that players like them because they like solving problems. Schell continues from that point with a definition that *games are entered willfully*. The internal value of games is created because the player wants to engage with the game and takes on the challenge.

The usefulness of educational games is unquestionable as found by de Freitas (2018) discussed previously. Stenros (2017) finds the productivity aspect of games to differ between definitions. Some definitions see games as leisure that does not produce anything of value, such as Huizinga's (1955b) but others consider social aspects of games as a productive output. Stenros notes that such output can be considered a fortunate by-product that is unrelated to the actual goal of the game.

Schell's (2015) notion that *games can create internal value* neither agrees nor disagrees. Schell argues that games create value for the players but the value is created within the game. Schell's definition sees players entering the world of the game and gaining value while within that world. These definitions fail to take into account games with a purpose outside of entertainment, though it is unclear whether the part that is *game* in educational games can provide value besides entertainment.

3.3 Physicality and connection to the world

Stenros (2017) notes that many definitions conflict on whether a game is an activity or a physical artifact being engaged with. He concludes that a game can be defined as both. Schell (2015) states that what differentiates games from toys is that *a toy is something you play with* whereas *a game is something you play*. For Schell (2015), a toy is an object but a game is more than just an object to be played with. This definition does not exclude the fact that a game might still require physical components.

Stenros (2017) brings up the conflicting nature of games where *game* is both a set of rules and a world within itself but also a concept that connects to the world around it. He notes that even strict definitions of *game* as just a closed system, such as Crawford's

(1984), mention the impact games have around them. Schell (2015) states that *games are closed, formal systems*. For him, games have a boundary called the *magic circle,* which he attributes to Huizinga (1955a).

Educational games in the DIL context are not disconnected from the world. As discussed in Chapter 2, Sparks et al. (2016) recommend real-world scenarios as effective tools to measure and teach DIL skills. The degree to which DIL games engage with the real world is important to consider when developing a DIL game.

Schell (2015) states that *games are interactive*. This notion connects the game to the world around it. If games are interactive, they have to be interacted with, which connects the game to the outside world. Interactivity is one of the major aspects that differentiate games from other media. Different games have different levels of interactivity, which can be measured and studied (Weber, Behr and DeMartino, 2014). High interactivity is linked to enhanced learning outcomes when compared to less interactive educational games (Lee *et al.*, 2011).

3.4 The role of the player

According to Stenros (2017) the role of the player differs between definitions. Some omit it entirely, such as Crawford's (1984) or have it implied, like Aarseth's (2014). Stenros notes that the role of the player is often something that is enforced by the game. In some instances, *player* refers only to the position of the implied user of *game,* and in others refers to the actual person experiencing the game. Schell (2015) concurs with *games engage players*. For Schell, player enjoyment is the core of games though he notes that being engaging can be called a quality of good games and that unengaging games are still games, just not of high quality.

DIL game development should emphasize the role of the player as they are not just experiencing the game but also learning from it. It is vital to decide how much freedom the player should be given in their learning to avoid the pitfalls discussed in section 3.2. This decision can be aided by *The Magic Bullet* model (Becker, 2009) discussed in Chapter 5.

3.5 Challenge and goals

Competition, conflict, and challenge are common among definitions of *game* as found by Stenros (2017). Schell (2015) agrees with *games have conflict*. For competitive multiplayer games the conclusion is obvious, but for single-player games Stenros

quotes Ellington, Addinall and Percival (1982) that in single-player games the competition or challenge is against the designer of the game.

Puzzles create issues with the definition of *game*, as they also provide challenges but differ structurally from games. Stenros (2017) says that it is unclear where the line between puzzles and games is. Schell concludes that the difference between puzzles and games is that puzzles cease to be fun when they are solved. Games are replayable but puzzles, like crosswords, are only fun once.

Discussion between puzzles and games is important for the DIL context: does a DIL game have to be replayable? If the main goal of a DIL game is learning, is such a solution necessary to be replayable if the learning outcomes have been met? An example of this is *Escape the Fake* (Paraschivoiu *et al.*, 2021), an augmented reality escape room game. While escape rooms are commonly referred to as games, their single-use form would consider them only as puzzles. In escape room games, one player or a team of players attempts to escape from a locked room. The key is hidden somewhere within the room behind a series of elaborate and thematic puzzles. Escape rooms are commonly physical rooms but they can be virtual as well.

Stenros (2017) finds that many definitions of *game* differ in their mention of a goal or an ending. He raises the question of whether games need to have a victory to have a goal or an ending. This discussion is not as useful for educational games as they have a distinct end state and goal: learning. According to Schell (2015), *games have goals*, which he derives from the discussions mentioned in Section 3.1.7 that *games have conflict* and that the conflict or contest of powers in a game results in a goal of victory for both sides. This is apparent in Schell's notion that *games can be won and lost*.

3.6 Meta-level findings

Stenros (2017) notes that definitions of *game* are influenced by situational factors. Different definitions have different scopes due to the fluidity of the subject. Simulations, sports, interactive fiction and puzzles among other game-related activities muddy the waters around what is and should be considered a game. Another meta-level finding from Stenros is that many definitions use lists of attributes as a tool to define *game*. While Schell (2015) does provide a compact one-sentence definition, he too provides a lengthy discussion and 10 qualities of *game*.

Trying to define *game* is a useful thought exercise for game developers but the exact definition is not necessary for DIL games. What is important is to tap into the educational potential of games without falling into the pitfalls of edutainment or edufication. To access this potential, the developer must understand the role of the player, the rules, and how interactivity benefits both the player and the educator. Recommendations for DIL games based on this Chapter are found in Chapter 6.

4 Digital Information Literacy games

Several DIL games already exist and many are likely in development. Some are made for research purposes, such as those discussed in this chapter. It is a worthwhile endeavor to learn from the successes and failures of previous studies on DIL games to improve further designs. This chapter begins with an introduction to *The fake news game* followed by an introduction of a game directly based on it called *The refugee crisis seen from Timisoara*. Then follows a discussion on the impact of *Bad News*, a game that followed *The fake news game*, to the larger field of DIL games and an overview of the field. Finally, a discussion on blind spots and potential for future research in the DIL games field.

4.1 The fake news game

The fake news game was a pilot study from Jon Roozenbeek and Sander van der Linden (2019b) to create an interactive multiplayer physical game to inoculate the players against disinformation. The game approaches disinformation using the inoculation theory, which sees misinformation as a social virus that can be "vaccinated" against by exposing the population to false information in a controlled way (van der Linden, 2017).

In the game, participants are divided into teams. Each team is then given a role, such as *the denier*, *the alarmist*, *the clickbait monger,* or *the conspiracy theorist*. They are then tasked to create a fake article from a set of article pieces using techniques appropriate for their role. The winning team is then the team with the largest amount of correct answers. (Roozenbeek and Van Der Linden, 2019b)

The fake news game fits into many definitions of *game* and uses many of the aspects of games mentioned in Chapter 3. Roozenbeek and van der Linden (2019b) found that the game was an effective educational tool but note that the small sample size in their pilot is not adequate for large-scale conclusions. They note that a major test for the inoculation theory in their game was the fact that the game uses a *refutational-different* format meaning it inoculates the participants against misinformation that is similar but notably not of the same topic as the one in the game. Traditionally inoculation has been used with the *refutational-same* format, where participants are inoculated against the same misinformation they will later be exposed to. The goal of the game was to give participants a more general and broad resistance. (Roozenbeek and Van Der Linden, 2019b)

4.2 The refugee crisis seen from Timisoara

The refugee crisis seen from Timisoara (Cernicova-Buca and Ciurel, 2022) is a game based on Roozenbeek and van der Linden's (2019b) *The fake news game*. Cernicova-Buca and Ciurel (2022) studied the effects of *The fake news game* but changed the topic to a more Romania-related refugee crisis topic. They replaced the original roles with *the reductionist*, *the alarmist*, *the sensationalist,* and *the conspirationist* though these roles closely resemble the ones from *The fake news game*. Cernicova-Buca and Ciurel achieved similar results compared to Roozenbeek and van der Linden (2019b) but with repeated testing noticed that the inoculation against misinformation did not last and that after six weeks in the repeat test, the participants' skills had diminished. Cernicova-Buca and Ciurel conclude that while the game was successful in sparking curiosity in the participants, further exposure and learning is needed for a more long-lasting effect. Similarly to Roozenbeek and van der Linden, they note that their study is not sufficiently large to draw major conclusions and that further study is needed to see if the results of the game are replicable.

4.3 Further research based on *The fake news game*

Kiili, Siuko and Ninaus (2023) note in their review of critical reading games the impact of *The fake news game* (Roozenbeek and Van Der Linden, 2019b) on the larger field of critical reading games. They report that an award-winning online game created based on *The fake news game* called *Bad News* by Roozenbeek and van der Linden (2019a) has been mentioned in 5 papers of the 15 reviewed. The concept has since been used in multiple games and studied extensively (Traberg, Roozenbeek and Van Der Linden, 2022).

In *Bad News* and similar games, the player is repeatedly prompted with choices, for example, whether or not to post a certain social media post, to gain as many followers as possible to grow their fake news empire. The game plays through several scenarios related to different types of approaches commonly used in misinformation. The game is played online through a web browser and uses many of the same approaches as *The fake news game*. (Roozenbeek and Van Der Linden, 2019a)

Kiili, Siuko and Ninaus (2023) describe these games as choice-based simulations where the player is put in the role of the misinformation producer and presented with a variety of prompts. Another common role identified by Kiili, Siuko and Ninaus (2023) found in the games is of the fact checker. In some games, the player is tasked to protect the internet from misinformation in various ways. All of the games reviewed either had

the player in the role of the misinformation producer or the fact checker. They also note that many of the games reviewed shared similar designs to *Bad News*.

Inoculation theory (Van der Linden, 2017) was found to be the prevalent approach against misinformation in these games (Kiili, Siuko and Ninaus, 2023). Traberg, Roozenbeek and Van der Linden (2022) in their further study of *Bad News* style games found that a 15-minute inoculation and regular booster tests had a decaying but lasting effect up to 13 weeks. The study did not continue further, so the effect may last longer.

A summary of the games reviewed by Kiili, Siuko and Ninaus can be found in Attachment 1.

4.4 Blind spots in DIL game studies

A major finding of Kiili, Siuko and Ninaus (2023), as discussed previously, is that many if not most of the games reviewed are similar in approach or design to *Bad News*. This indicates that further study in other forms of inoculation or DIL games in general, is needed to get more generalized results.

Kiili, Siuko and Ninaus (2023) also found that the majority of the studies were conducted on adults leaving a large, vital and vulnerable group unstudied: children and adolescents. They note that none of the studies were done in formal education settings, leaving a major gap in the educational possibilities. Additionally, they lament that the studies had inconsistent evaluation methods and call for a standardized or unified metric to study the effects of DIL games.

Finally, Kiili, Siuko and Ninaus (2023) find that the studies had inadequate descriptions of the games used in the studies and that none of the studies used motivational theories (Krath, Schürmann and Von Korflesch, 2021) usually found in game design. This suggests that further studies on DIL games should incorporate more game design literature and research.

5 Evaluating DIL games

While the field of DIL games remains small and academically sound as DIL games are mostly created for academic studies, there is a distinct possibility that the DIL game market grows larger and more commercially motivated in the future. Educators and researchers need ways to study and understand new DIL games to better choose which to study academically or use in teaching. This chapter introduces an example model for evaluating educational games, followed by a larger framework that expands the scope of how frameworks can be used to model these games. Finally, a short discussion on how researchers can select the best frameworks for evaluating educational games.

5.1 The Magic Bullet model

The Magic Bullet is an evaluation model for educational games by Katrin Becker (2009). The framework consists of the following five categories:

Can: Games have things players can learn. These are the things the designers intended to be learned from the game. There has to be enough to be learned and experienced for the game to feel full.

Must: A subset of things players can learn is things players must learn. These are things that are needed to complete the game. If the game has multiple branching ways to win, players might learn different things on the way. If the game is one-dimensional, all players will generally learn the same things.

Collateral learning: Besides things players *can* learn there are things players might learn unintentionally or collateral learning. There are things players might learn that the designers did not intend them to learn, which is often seen as negative by educators. They are afraid of losing control of the contents students are exposed to when using interactive education online. This issue can be avoided by having educators study the tools and games beforehand.

Cheats are tools left in the game by developers for testing purposes. Players should not be able to use them but occasionally they might learn how to access these cheats.

Did: Finally, there are things players did learn. This category should include everything in the must-learn category if the player wants to win the game or succeed at a sub-goal.

The Magic Bullet is brought up as an example of frameworks used to evaluate DIL games and their learning potential.

5.2 Effective GBL

Effective Game Based Learning (Effective GBL) is a general-purpose framework for evaluating game-based learning by Connolly, Stansfield and Hainey (2008). The framework was created based on a literature review of existing frameworks to combine different more granular frameworks into a large overview.

The framework consists of seven dimensions:

Learner Performance: Measuring learner performance is important to understand whether the game improves the skills and knowledge of the learner.

Motivation: The learner's engagement should be studied both before and during the game. What motivates the learner, how much and why?

Perceptions: The learner's subjective experience of the game and the general learning experience.

Attitudes: How learner and instructor attitudes affect the learning experience

Preferences: Different learners and instructors have different preferences on how they like to learn and teach.

Collaboration (optional): Some learning games are played with other people. In these cases, the collaboration aspect should be measured and monitored.

GBL environment: GBL environment is the most complicated part of the Effective GBL framework. It consists of five subcategories:

Environment: Environment within GBL environment refers to multiple environmental factors. Both the physical learning environment and a possible virtual environment the game is played in. An example of this would be game difficulty or game assets themselves.

Scaffolding: Scaffolding refers to the instructions and feedback given to players.

Usability: Usability can be measured through for example error rates or completion time.

Level of social presence: Social presence refers to interactivity and how immersed the player is within the game world and its characters.

Deployment: Deployment refers to how the GBL solution is best implemented in a learning context.

Connolly, Stansfield and Hainey (2008) note that all categories in the *Effective GBL* framework can be divided into subcategories, or in the *GBL environment* case each subcategory divides further. They recommend using unique frameworks to measure each subcategory, many of which have their own respective research papers.

Effective GBL illustrates how large and complex the field of educational games is. Each category and subcategory can be evaluated independently with a large number of differing frameworks.

5.3 Framework selection

Selecting appropriate frameworks to evaluate learning potential and effectiveness in DIL games is complicated due to the number of existing frameworks and categories. Tahir and Wang (2019) in their comparative analysis of educational game design models discuss and compare different models and their evaluation. They note that the goal of comparing models is to not find which is the best but instead to compare their respective strengths and weaknesses. A major finding of Tahir and Wang is that no design model in their review was able to address all of the topics reviewed, which suggests that multiple frameworks should be used in conjunction while developing DIL games. Comparison of frameworks can be done using the lenses used by Tahir and Wang (2019) listed in Attachment 2.

Tahir and Wang find that the majority of the frameworks focus on learning and game factors. They suggest that the design stage of DIL game development should focus on merging learning and game mechanics, and consider for example enjoyment, usability, or environment with lesser priority.

Tahir and Wang also find that the majority of frameworks have not been properly evaluated or used in a practical setting. They note that the lack of tools hinders the usability of these design models in practice. Finally, they note that practical use of these models in the industry may be lacking if companies have not made use of the results public and call for collaboration between researchers and companies.

Framework selection is not a simple endeavor. Fortunately, research such as Tahir and Wang's (2019) framework analysis and the *Effective GBL* framework (Connolly, Stansfield and Hainey, 2008) can enlighten researchers and educators.

6 Discussion

Understanding digital information literacy games is a large endeavor due to the multidisciplinary nature of educational games. Educators might be able to evaluate the quality of certain games using frameworks and tools, provided they have access to resources that help them select proper frameworks such as the research by Tahir and Wang (2019). As demonstrated by *Effective GBL* (Connolly, Stansfield and Hainey, 2008), educational games are very complex and require many fields of research to have a complete understanding of their nature, suitability, and effectiveness.

The field of DIL games is promising but narrow. As demonstrated by Kiili, Siuko and Ninaus (2023), many of the existing solutions are quite similar to *Bad News* in their approach and design. There are also major blind spots in the DIL game studies as discussed in Chapter 4. Most importantly, DIL games have proven effective in inoculating people against misinformation but the effects of these games do not last. Further research is needed to figure out how the effect of inoculation can be extended and how DIL game solutions can be scaled up.

Future studies on DIL games should be conducted with interdisciplinary teams that combine an understanding of DIL with game designers, game researchers and educators to avoid the pitfalls of edutainment and edufication. Educators may have an inadequate understanding of games as educational tools. Therefore, as DIL games expand into classrooms, educators need resources that help them understand both the possibilities and caveats of educational games.

Media literacy is already part of many curriculums and teachers are able to teach it without DIL games. However, full mastery of DIL requires other, more active components in addition to critical reading. DIL games are uniquely able to meet this demand as they are interactive and engaging. With the rise of AI LLMs, future students might be able to safely learn, for example, how to interact online through simulated interactions. AI can be trained to replicate disinformation techniques commonly used in online news and also illustrate how these techniques can be spotted. Alternatively, AI can be trained to respond to messages in a way that resembles real online forums.

Digital information literacy and critical reading skills will be vital for answering the challenges posed by our current and future information landscape. These skills cannot, however, be learned only by reading as they demand active learner participation. Interactive learning experiences, such as DIL games, are a promising way to achieve that active learning.

6.1 Methodology for DIL game development

Based on the findings in this thesis, I propose the following guidelines for developers and researchers to use in DIL game projects:

What is DIL: Every person working on a DIL game project should be familiar with the concept of DIL. Sources from Chapter 2 can be used to learn about DIL. Best practices found by Sparks, Katz, and Beile (2016) should be used in development.

> *A performance based assessment of DIL that presents information problems in a wide range of personal, workplace, and academic contexts and aligns to widely accepted aspects of the construct appears to be a particularly useful option for meeting the needs of higher education institutions.* (Sparks, Katz and Beile, 2016)

Table 1: Summary of best practices for DIL evaluation and education based on research by Sparks, Katz and Beile (2016)

Defining DIL	Use high-level concepts to describe DIL and measure holistically, if possible. A more granular and precise definition can be used for automated scoring.
Real-life scenarios	Use relevant real-life scenarios when assessing and teaching DIL for improved learning.
Avoid specific knowledge	Make sure players are able to engage with the game without knowledge of technology or specific fields. Teach necessary vocabulary and skills beforehand.
Automate scoring	While not optimal, technology is sufficient for automated evaluation of DIL skills and currently the only option for large scale use.
Report comprehensively	Institutions conducting DIL studies need big-picture information. However, single learners also benefit from personalized and precise information about their skills.

Why games: Be sure to understand what unique advantages games bring. Not everything should be a game. Edufication and edutainment create lackluster products that are neither good games nor good education. Games are difficult and expensive to create, so they should only be used when their advantages are utilized properly. Research, such as by Stenros (2017), can be used to understand the concept of games and books, such as Schell's (2015), provide more concrete guidance.

Table 2: Aspects of games and how they benefit education
based on research by Stenros (2017) and teachings of Schell (2015)

Games have rules and structure	Rules and structure provide a framework for the players to engage with.
Games have purpose	Games usually entertain but game-like structure can be used to educate, study, or simulate. The entertainment value of games can exist concurrently with other purposes.
Games connect to the player	Games are uniquely interactive. This interactivity can be co-opted for enhanced learning.
Games provide challenge	Games are unique in that they provide challenges the players interact with wilfully.

This list is not an exhaustive collection of guidelines or necessarily a proper framework for success. Many complex frameworks have been created to understand the potential of educational games. These frameworks are discussed in Chapter 5.

The Team: Games are complicated and large. Consequently, a team creating a DIL game should contain professionals of multiple fields:

Game designers: Designers are experts of engagement. Their core competence is to know what works, what does not and what has been tried before. It is the job of the designer to bring forth the unique value of games. Effective GBL: Motivation

Educators: Educators are professionals in knowing what information should be taught and how it should be structured. Educators are responsible for the learning content of the game. Effective GBL: Learning Performance, Perceptions

User researchers: DIL games will be deployed in classrooms and education contexts. User researchers make sure the final game is usable in the field. Effective GBL: GBL environment

Artists, programmers and other creative professionals: Polish makes and breaks games. Professional artists and programmers can make the game the best it can be. Players are more willing to play a well working and aesthetically pleasing game. Effective GBL: Perceptions, Attitudes

What has been done: Developers should know what games have been made before and what the results of those games were. Research, such as by Kiili, Siuko and Ninaus (2023), can be used to get an overview of the field. A summary of papers reviewed by Kiili, Siuko and Ninaus can be found in Attachment 1.

Frameworks: Evaluation tools should be used to understand the impact of prototypes and the eventual final product. Effective GBL (Connolly, Stansfield and Hainey, 2008) can be used to select aspects that are seen as most important, and the lenses and research by Tahir and Wang (2019) can be used to select more precise frameworks for certain aspects of development. The lenses can be found in Attachment 2.

6.2 Future research

Based on the findings in this thesis, I propose the following subjects for further study:

Children and educational contexts: Kiili, Siuko and Ninaus (2023) found that DIL game studies were only conducted on adults. While improving the DIL skills of adults is important, DIL education should have priority. Children will have to live in the digital information ecosystem and society must provide them with adequate tools.

Online interaction and the potential of AI: Research on large language models has recently made large leaps. AI systems are now being considered for use in many industries. The potential of AI for DIL education should be studied, especially for simulating interactions online.

Effectiveness on inoculation: Current studies have shown that inoculation theory is an adequate approach to combatting disinformation. Studies should focus on extending the effect of inoculation as current solutions require constant boosters to keep up the effects.

Widen the approach and audience: Kiili, Siuko and Ninaus (2023) found that most DIL game studies focused on similar approaches, specifically choice-based simulation. New games should aim to expand the field and create unique experiences. Most of the research was only small in scope. Larger and more quantitative research is needed to verify the findings.

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Attachments

Attachment 1: Summary of papers reviewed by Kiili, Siuko and Ninaus

Source: Kiili, Siuko and Ninaus (2023)

Game	**Narrative**	**Source**
Go Viral! Choice-based simulation	Play as a social media influencer and spread misinformation about COVID-19	(Basol *et al.*, 2021)
ChamberBreaker Choice-based simulation	Share biased tweets to form an echo chamber effect in SNS	(Jeon *et al.*, 2021)
Bad News Choice-based simulation	Produce fake news to gain popularity and credibility as a news publisher	(Maertens *et al.*, 2021)
Escape the Fake AR-based escape room adventure with quizzes	Save the world by recognizing fake news	(Paraschivoiu *et al.*, 2021)
Trustme! Choice-based simulation	Play as a famous influencer who has to help checking reliability of information	(Yang *et al.*, 2021)
Bad News Choice-based simulation	Produce fake news to gain popularity and credibility as a news publisher	(Basol, Roozenbeek and Van Der Linden, 2020)
FakeYou Competitive multiplayer game	N/A	(Clever *et al.*, 2020)
UNISON Cooperative board game	N/A	(Maze *et al.*, 2020)
Bad News, Fakefinder Choice-based simulation	N/A	(Pimmer, Eisemann and Mateescu, 2020)
Harmony Square Choice-based simulation	Play as a fake news producer to foment internal divisions in neighborhood	(Roozenbeek and Van Der Linden, 2020)
Factitious Multiple choice quiz (true or false)	Identify fake news	(Grace and Hone, 2019)
MAthE the Game N/A	Play as a fact inspector to identify fake news	(Katsaounidou *et al.*, 2019)
Bad News Choice-based simulation	Produce fake news to gain popularity and credibility as a news publisher	(Roozenbeek and Van Der Linden, 2019a)
Fake news game Competitive card game	Create fake news that reflect goals and motivations of provided characters	(Roozenbeek and Van Der Linden, 2019b)
Bad News Choice-based simulation	Produce fake news to create a successful fake news website	(Scheibenzuber and Nistor, 2019)

Attachment 2: Lenses used by Tahir and Wang

Source: Tahir and Wang (2019)

Analytical lens	**Description**
GBL Attributes (Tahir and Wang, 2017) (Tahir and Wang, 2018)	How many and which GBL attributes are covered by the educational game design model/framework?
Learning/pedagogical	Does the model/framework consider learning/pedagogical attribute, or any elements related to it?
Game factor	Does the model/framework consider game factor attribute, or any elements related to it?
Affective Reactions	Does the model/framework consider affective reaction attribute, or any elements related to it?
Usability	Does the model/framework consider usability attribute, or any elements related to it?
User	Does the model/framework consider user attribute, or any elements related to it?
Environment	Does the model/framework consider environment attribute, or any elements related to it?
Validity (Dos Santos and Fraternali, 2016) (Abrahamsson, Oza and Siponen, 2010) (Tripathi, Kumar and Shrivastava, 2009)	Does the model/framework have support for its claims?
Theoretical evidence (Development basis)	Is the model/framework grounded in appropriate theory? (author provide development basis for the model/framework).
Empirical evidence (Validation/application)	Does the model/framework have empirical support for its claims? (details of application/validation of framework/model: game name, sample size, validated elements).
Framework attributes (Dos Santos and Fraternali, 2016) (Abrahamsson, Oza and Siponen, 2010) (Babar and Gorton, 2004) (Yusof and Rias, 2015)	What type of attributes are provided by the model/framework?
Tool/ instrument Support	Does the model/ framework offer tool/instrument support for its artefacts?
Assessment and stakeholders	What types of assessment approaches are used for the model/framework? Which groups of stakeholders are required to participate in assessment?
Applicable Stage	What is the most appropriate educational game development lifecycle phase(s) to apply the model/framework?
Application domain	In which application domain(s) the model is mostly applied?
Guidance for application (abstract principles vs concrete guidance)	Does the model/framework rely only on abstract principles or it provides concrete guidance? (offer guidelines on how to practically use it for educational game design)

Target/adaptability	Is the model/framework fit for all educational games (universal/ generic) or is it situation appropriate (specific)? Does it offer adaptability in actual use?
Strength/weakness	What are the strengths and weaknesses of the model/framework?