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REVIEW ARTICLE

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# Tackling misinformation with games: a systematic literature review

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**ABSTRACT**

Misinformation and fake news are severe threats to society. The role of critical reading skills is crucial in the battle against misinformation. Despite the promising results of game-based interventions to mitigate the effects of misinformation, the corpus of research on games supporting critical reading skills needs an overview. Therefore, a systematic literature review was conducted to analyze how games have been used to tackle misinformation and reveal game design trends. A total of 15 papers eventually met the defined inclusion criteria and were analyzed. The review revealed that the use of games in critical reading education had emerged recently and focused mainly on fake news. Most games were grounded on inoculation theory and consequently designed to expose players to weakened doses of the misinformation manipulation techniques to build resistance against them. So far, the games have been studied mainly in informal settings and with adult participants. The median sample size was 196, and the median playing time was 15 min across the studies reported in the papers. Although all the reviewed papers reported positive outcomes, the game-based learning research on the critical reading domain is not yet mature enough to generalize findings.

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Game-based learning; gamification; critical Reading; misinformation; fake news; inoculation theory

## Introduction

One of the main challenges of our times is the rapid spread of misinformation and disinformation on the Internet (Kendeou et al., 2019). Misinformation refers to incorrect information created and disseminated for some reason without any intention to mislead audiences (Eva et al., 2021). In contrast, disinformation, a sub-dimension of misinformation, is intentionally created and disseminated to mislead audiences (Eva et al., 2021). Recently, the "fake news" term has become more common in discussions about misleading information. According to Pierri and Ceri (2019), the "fake news" term has been extensively used to refer to disinformation, misinformation, hoaxes, propaganda, satire, rumors, clickbait, and junk news. Fake news has been defined as "fabricated information that mimics news media content in form but not in organizational process or intent" (Lazer et al., 2018, p. 1094).

In contrast to real news, fake news aims to deliver false information in a convincing way to the audience. Fake news has been primarily associated with political topics, and recently, topics such as vaccination, nutrition, and stock values have become more common (Lazer et al., 2018). While

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misinformation and fake news have caused problems since the early days of mass communication, the rise of social media platforms has amplified the problems (Velichety & Shrivastava, 2022). The scientific literature also reflects the emergence of the fake news phenomenon, as the number of research papers on fake news has radically increased during the last five years (Xu et al., 2022).

Technological advancements to automatically generate fake content (Giachanou et al., 2022) and the increasing amount of information on the internet pressure society to find effective and efficient ways to eliminate the unintended effects of misinformation. Although several technical approaches to detect fake news have been proposed, accurate detection is challenging (Kozik et al., 2022). Thus, the readers' role in the battle against the spread of fake news and misinformation is crucial. Accordingly, our education system should be able to equip all citizens with adequate critical reading skills.

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). According to Salmerón et al. (2020), critical reading is a sequential process in which source characteristics play a crucial role: 1) paying attention to source characteristics, 2) evaluating "the quality of the information by judging to what extent these source characteristics suggest that the information is supported by sound evidence" (p. 1038), and finally 3) concluding the quality and trustworthiness of the information (e.g. accepting the source and information as credible or discarding as a potentially biased source). The credibility judgments can also be considered in light of a bidirectional model of first- and second-hand evaluation strategies (Barzilai et al., 2020). First-hand evaluation strategies refer to the evaluation of information validity. This evaluation is based on the reader's prior knowledge and beliefs. If the reader is not satisfied with the first-hand evaluation, the reader can evaluate the source's trustworthiness by using second-hand strategies. In other words, it is about judging whether the author or the source of information can be trusted or not. The ability to evaluate source characteristics such as the authors' expertise and motives and publication venue are essential competencies of critical readers.

The central question is whether our education system has prepared all students with sufficient critical reading skills to help them analyze, evaluate, and interpret conflicting, fake, and misleading information. Previous research suggests that this is probably not the case (Hämäläinen et al., 2020; Kiili et al., 2017; Kiili et al., 2019), and there are worrying signs of the polarization of critical reading skills (Kiili et al., 2017; Leu et al., 2014). In fact, regardless of different attempts to help people learn to recognize misinformation, many still believe in fake content and share it online (Giachanou et al., 2022). Moreover, despite increasing research on different perspectives on misinformation, the theoretical understanding of interventions to eliminate the unintended effects of misinformation is still limited (Eva et al., 2021). Scholars have proposed both pre-emptive (prebunking) and reactive (debunking) interventions to tackle misinformation (Ecker et al., 2022; Van Der Linden, 2022; van der Linden et al., 2021).

Pre-emptive interventions aim to help people recognize and resist subsequently encountered misinformation. Sophisticated pre-emptive interventions are based on inoculation theory (Ecker et al., 2022). These interventions apply the principles of vaccination to knowledge, which means that people are "inoculated" with a weakened form of persuasion (misinformation) to build immunity against similar attempts faced in the future (Traberg et al., 2022; Van Der Linden, 2022). Inoculation theory is based on two main mechanisms (Compton et al., 2021; Van Der Linden, 2022). First, the aim of forewarning is to motivate resistance (a desire to defend oneself from manipulation attacks). Second, the aim of a pre-emptive refutation (pre-exposure to a weakened example of the manipulation attack) is to provide people with specific knowledge that they can use to refute future manipulation attacks.

In contrast, reactive interventions are administered after exposure to misinformation to demonstrate why specific misinformation is false (Ecker et al., 2022). The drawback of the reactive approach is that some people are motivated to reject scientific evidence. Thus, even repeatedly provided

scientific evidence tends to have little impact (Hornsey & Fielding, 2017). Therefore, pre-emptive interventions seem to be more promising as they not only address specific misinformation but may help people build resistance to misinformation in a relatively general manner.

Further, recently, scholars have proposed game-based learning as a promising intervention approach to tackling misinformation (Ecker et al., 2022; Traberg et al., 2022). Interactive games are seen as useful intervention approaches as they can provide "active" inoculation, which is suggested to be more effective than "passive" inoculation (e.g. reading campaigns) (Banas & Rains, 2010; Ecker et al., 2022; Traberg et al., 2022). Cook et al. (2023) emphasize that, unlike passive inoculation, active inoculation is a two-way process through which players engage interactively with inoculated game content. For example, the humorous Cranky Uncle game, which was published after the current systematic review of the literature, is based on an active inoculation approach (Cook et al., 2023). In the game, Cranky Uncle delivers deadpan explanations of how he can deny scientific evidence about climate change using obviously fallacious reasoning. The players interact with Cranky Uncle and actively practice spotting these fallacies and denial techniques in a story-driven context.

In the current paper, we systematically review the use of game-based and gamified learning environments designed to support critical reading skills needed in the battle against misinformation. For the sake of simplicity, we will use the term *games designed to support critical reading skills* to refer to different kinds of game-based and gamified learning environments that are designed to support people in encountering misinformation.

## Present study

In recent years, the use of game elements in learning environments has increased remarkably (Sailer & Homner, 2020). Game-based learning, serious games, and gamified learning are partly overlapping instructional approaches in which game elements are used to enhance learning outcomes (Krath et al., 2021). Several literature reviews have documented research efforts in these instructional fields and revealed trends in using games for educational purposes. For example, Krath et al. (2021) reviewed the theoretical foundations of gamification, serious games, and game-based learning research. Their review revealed that scholars had based their studies and game designs on 118 different theories. In this context, games are also applied in a large variety of subjects, content domains, or areas. For example, recent reviews have indicated that STEM subjects are the most popular application areas in the game-based learning field (Boyle et al., 2016; Hainey et al., 2016). On the other hand, when considering research on game designs, points, leaderboards, and badges are found to be the most frequently used game mechanics in gamified learning (Zainuddin et al., 2020). In general, although the research on game-based learning is fragmented, a growing body of evidence indicates that game-based learning can be more effective than conventional instructional methods (Clark et al., 2016; Wouters et al., 2013).

Despite the growing spread of misinformation and promising results of game-based interventions to mitigate its effects, only narrative reviews on this topic have been published so far (e.g. Traberg et al., 2022). Thus, it is essential to systematically review the previous research on games designed to support critical reading skills to understand how games have been used to fight misinformation. More importantly, the critical question is how the existing knowledge on interventions to fight misinformation has been applied in the design of the reviewed games. Regarding the games designed to support critical reading skills, our specific purposes for this review were:

- to provide an overview of the scope, media context, and topics of the games
- to identify fundamental theories that have been utilized in designing the games
- to document game design trends in the games
- to provide an overview of the outcomes of the games
- to draw implications for future research and practice

## Review method

### Research design

A two-phase literature search strategy was used, including a database search and a reference search. First, we conducted the database search using Scopus, IEEE Xplore, APA PsycNet, and SAGE Journals databases. Second, after screening the papers identified with a database search, we searched for relevant papers from the reference list of the included papers. The reference list search aimed to ensure that we included the most relevant publications allowing us to address the review's objectives.

### Data collection and search terms

We used a search query to search the databases within the title, abstract, and keywords of the articles. The search query was as follows: TITLE-ABS-KEY ((“epistemic games” OR “mobile games” OR gamification OR gamified OR “game-based” OR “game based” OR “serious game” OR “learning game” OR “educational game” OR “video game” OR “board game” OR dgbl OR gbl OR “educational simulation” OR “learning simulation”) AND (“fake news” OR “disinformation” OR “misinformation” OR “trustworthiness” OR “credibility” OR “misleading” OR “news literac*” OR “media literac*” OR “media education” OR “data literacy” OR “graph literacy”)). Only articles that were published before 2022 and written in English were searched from the databases. The search was conducted in January 2022.

### Inclusion criteria and selection of papers

Figure 1 presents the paper selection flowchart using the PRISMA guidelines (e.g. Moher et al., 2009). With the database search, we identified 285 paper candidates (duplicates excluded) for review. After the database search, the papers were screened against the inclusion criteria.

We formulated criteria that guided our selection of papers for the final analysis of research on games designed to support critical reading skills. To be included in the present systematic literature review, a paper had to meet the following criteria:

- The paper must include a game targeted at training critical reading skills. When judging whether the included learning activity could be considered a game, we used Salen and Zimmerman's (2004) game definition, according to which a game is “a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome”. To concretize this definition, we expected that the game-playing process consists of challenge-response-feedback loops, as suggested in the game-based learning model (Plass et al., 2015).
- The paper must report the results of an original empirical study investigating the game designed to support critical reading skills. The study could focus on cognitive, behavioral, or affective outcomes.
- The paper must be written in English.

The screening was carried out in two phases: 1) title and abstract screening and 2) full-text screening. The first screening phase was conducted by the second and third author of the paper. Both screened all the identified 285 papers. If the inclusion could not be conclusively determined based on the information presented in the abstracts and titles, these papers were included in the full-text screening phase. Overall, 30 papers were deemed to be appropriate for full-text screening. The Cohen's Kappa statistic was used to examine the interrater reliability for the records screened in the first phase. According to Cohen (1960) there was strong agreement between the two reviewers' screening results ($\kappa = .83$, $p < .001$); in case the screening results differed, the agreement was reached through discussions. The second screening phase was conducted cooperatively by all authors. In the

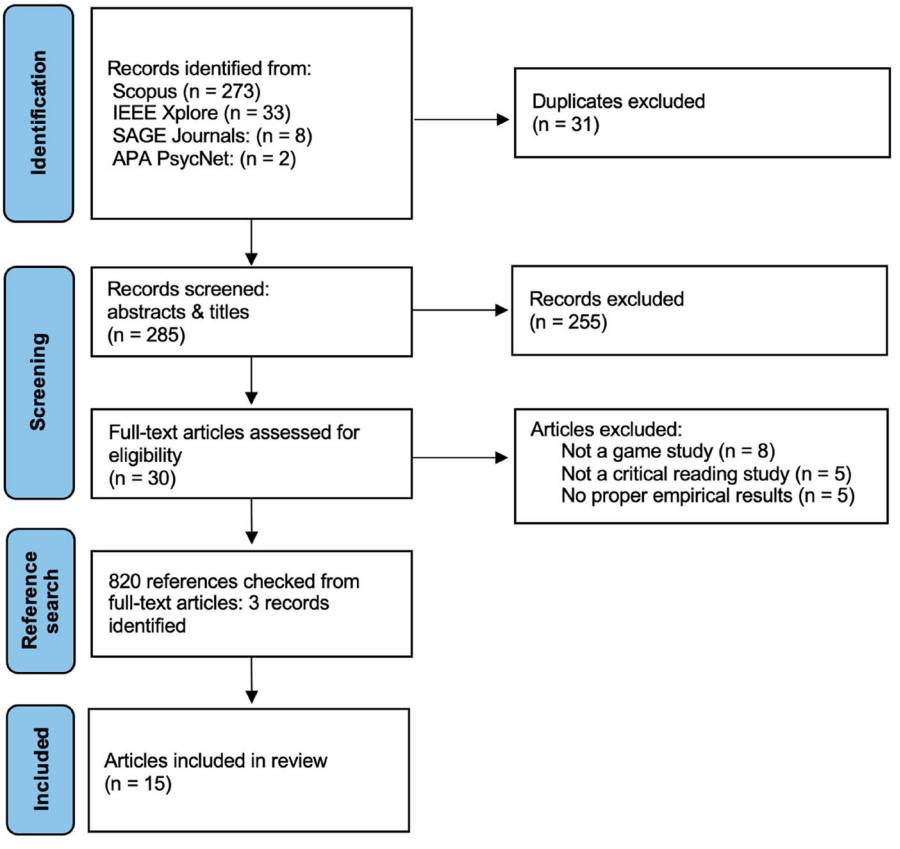


**Figure 1.** Paper selection flowchart.

full-text screening phase, 18 papers were excluded: eight papers did not include a game that was investigated, five papers did not include a critical reading aspect, and five papers did not report empirical results adequately, resulting in 12 included papers. After the screening, we searched through the reference lists in each of these 12 papers. With this, we wanted to ensure not to miss any relevant papers. We identified three additional papers that were included in the review, resulting in 15 papers.

## *Coding of papers*

As a mechanism for identifying trends and patterns in the included papers, we read and coded each paper in several ways. Along with the basic entries of author(s), year of publication, publication type, number of participants, age of participants, research design, and the main research outcomes, we documented the main characteristics of the games. Game-related aspects were documented based on game descriptions, pictures, and web links.

First, we documented the games' names, topics, and media contexts. With media context, we refer to different modes used to present the game's critical reading content/stimuli. For instance, fake news articles, fake news headlines, social media posts, videos, memes, and online texts were used in different studies.

Second, we documented the misinformation manipulation techniques addressed in the games and the theoretical basis of the games. We did not create our coding scheme for misinformation manipulation techniques; instead, we documented them as written in the papers. Emotionally

evocative language, fake experts, conspiracy theories, trolling, polarizing audiences, and exaggeration are examples of documented manipulation techniques.

Third, we analyzed the main characteristics of the games. We documented the narrative approaches, core learning mechanics, and feedback and incentive systems included in the games. We used these characteristics to identify common game design trends in games. Moreover, based on the documented misinformation manipulation techniques, the theoretical basis, and the characteristics of the game, we classified the games either as pre-emptive or reactive game interventions (please note that classification was not possible for each game due to insufficient game descriptions).

Finally, to shed light on the scientific impact of the papers, we documented the Field-Weighted Citation Impact (FWCI) of the papers (extracted from Scopus). According to Purkayastha et al. (2019, p. 636), "Field-Weighted Citation Impact (FWCI) is an indicator of mean citation impact and compares the actual number of citations received by a document with the expected number of citations for documents of the same document type (article, review, book, or conference proceeding), publication year, and subject area. The metric is always defined with reference to a global baseline of 1.0 and intrinsically accounts for differences in citation accrual over time, differences in citation rates for different document types (e.g. reviews typically attract more citations than articles), as well as the subject-specific difference in citation frequencies overall and over time and document types." FWCI values were retrieved in April 2022.

## Results

To simplify the reporting terminology, we will use the term "player" to refer to the player, user, or participant, the term "game" to refer to game-based learning, a serious game or a gamified learning system, and the term "paper" to refer to both journal and conference articles. We report the review results in four sections: 1) Publication trends and impact, 2) Media contexts, scope, and theoretical basis of the games, 3) Identified game design trends, and 4) Study methods and overall outcomes. As described in the method section, 15 papers formed the basis for this review. The included articles are summarized alphabetically by year in Table 1.

### *Publication trends and impact*

First, Table 1 indicates that all the papers were published during 2019–2021. Second, we explored the publication types of the papers. Sixty percent of the papers were journal articles, and the rest

**Table 1.** Details of the reviewed papers: authors, publication year, publication type (J = Journal; C = Conference), references, and Field-Weighted Citation Impact (FWCI). * If includes authors from the University of Cambridge.

| Paper Id | Authors | Year | Type | References | FWCI |
|---|---|---|---|---|---|
| 1* | Basol, M., Roozenbeek, J., Berriche, M., Uenal, F., McClanahan, W. P., & Linden, S.V.D. | 2021 | J | 67 | 12.2 |
| 2 | Jeon Y., Kim B., Xiong A., Lee D., Han K. | 2021 | J | 82 | 0.65 |
| 3* | Maertens, R., Roozenbeek, J., Basol, M., & van der Linden, S. | 2021 | J | 111 | 20.99 |
| 4 | Paraschivoiu I., Buchner J., Praxmarer R., Layer-Wagner T. | 2021 | C | 32 | 4.32 |
| 5 | Yang, S., Lee, J. W., Kim, H. J., Kang, M., Chong, E., & Kim, E.M. | 2021 | J | 71 | 2.74 |
| 6* | Basol, M., Roozenbeek, J., & van der Linden, S. | 2020 | J | 30 | 13.59 |
| 7 | Clever, L., Assenmacher, D., Müller, K., Seiler, M.V., Riehle, D.M., Preuss, M., Grimme, C. | 2020 | C | 22 | 1.86 |
| 8 | Maze, C., Haye, A., Sarre, J., Galaup, M., Lagarrigue, P., & Lelardeux, C.P. | 2020 | C | 20 | 0.62 |
| 9 | Pimmer, C., Eisemann, C., & Mateescu, M. | 2020 | C | 11 | 0.76 |
| 10* | Roozenbeek, J., van der Linden, S. | 2020 | J | 36 | N.A. |
| 11 | Grace, L., & Hone, B. | 2019 | C | 20 | 2.11 |
| 12 | Katsaounidou, A., Vrysis, L., Kotsakis, R., Dimoulas, C., & Veglis, A. | 2019 | J | 48 | 3.38 |
| 13* | Roozenbeek, J., & Van der Linden, S. | 2019a | J | 76 | 43.91 |
| 14* | Roozenbeek, J., & Van der Linden, S. | 2019b | J | 76 | 19.22 |
| 15 | Scheibenzuber, C., & Nistor, N. | 2019 | C | 7 | 0.73 |

were conference papers. Third, we used Field-Weighted Citation Impact (FWCI) to consider the scientific impact of the papers. FWCI of seven papers was above the global baseline of 1.0. The impact of the papers (Basol et al., 2020; Basol et al., 2021; Maertens et al., 2021; Roozenbeek & van der Linden, 2019a; Roozenbeek & van der Linden, 2019b) can be considered very high as these papers were cited at least 12 times more than the global average. These five papers included authors from researchers working at the University of Cambridge who developed, for example, an award-winning game called Bad News.

### *Media contexts, scope, and theoretical basis of the games*

Table 2 summarizes the topics, media contexts, misinformation manipulation techniques, and theoretical basis of the reviewed games. Altogether 12 different games were described in the papers. Only one game, Bad News, was investigated in several papers (five papers). Our analyses revealed that

**Table 2.** Topics, media contexts, manipulation techniques, and the theoretical basis of the games included in the reviewed papers.

| Paper Id | Game | Topics | Media contexts | Misinformation manipulation techniques | Theoretical basis |
|---|---|---|---|---|---|
| 1 | Go Viral! | Missinformation on COVID-19 | Social media posts | Emotionally evocative language, fake experts, conspiracy theories | Inoculation |
| 2 | ChamberBreaker | Health, political, environmental | Social networking service: tweets | Echo chamber: social boundaries, user similarity, information homogeneity, | Inoculation, heuristics |
| 3 | Bad News | N.A. | Fake news: tweets, headlines, memes | Discrediting opponents, appealing to emotion, polarizing audiences, impersonation, floating conspiracy theories, trolling | Inoculation |
| 4 | Escape the Fake | Refugees, climate | Fake news | N.A. | N.A. |
| 5 | Trustme! | Political, commercial | Online texts | Falsity, human error, intentional manipulations (motives) | Inoculation |
| 6 | Bad News | N.A. | Fake news: Twitter Tweets, headlines, memes | Impersonating people online, using emotional language, group polarization, spreading conspiracy theories, discrediting opponents, trolling | Inoculation |
| 7 | FakeYou | N.A. | Fake news: headlines | N.A. | N.A. |
| 8 | UNISON | N.A. | Fake news: articles, videos, pictures | Satire or parody, false connection, misleading content, impostor context, manipulated content, false & fabricated context | N.A. |
| 9 | Bad News, Fakefinder | N.A. | Fake news | N.A. | Inoculation |
| 10 | Harmony Square | Political | Fake news | Trolling, using emotional language, polarizing audiences, spreading conspiracy theories, artificially amplifying the reach of content through botsand fake likes | Inoculation |
| 11 | Factitious | N.A. | Fake news | N.A. | N.A. |
| 12 | MAthE the Game | N.A. | Fake news | Pseudoscience, image out of context, image manipulation | N.A. |
| 13 | Bad News | N.A. | Fake news: tweets, headlines, memes | Polarization, invoking emotions, spreading conspiracy theories, trolling, deflecting blame, impersonating fake accounts | Inoculation |
| 14 | Fake news game | Immigration | Fake news | Denial, exaggeration, conspiracy theories, clickbait | Inoculation |
| 15 | Bad News | N.A. | Fake news: tweets, headlines | Strategies to create fake news (not specified) | Inoculation |

fake news was the most common media context of the games (80% of the papers). In general, the fake news and misinformation included in the games took different forms, such as social media posts, news articles, headlines, and memes. The topics (content) of the games were related to political, environmental, commercial, and health issues. Surprisingly, nine of the papers did not specify any particular topic. Fortunately, the included misinformation manipulation techniques were described better. Eleven papers reported the manipulation techniques that the games included.

Consequently, we identified 12 papers that included games that can be classified as pre-emptive interventions (note that one of these papers did not report the exact techniques). In general, these game-based interventions aimed to expose players to severely weakened doses of the manipulation techniques encountered in real life to build resistance against them. In line with this finding, inoculation theory (Compton et al., 2021; Ecker et al., 2022) was the most common theoretical basis of the games. Additionally, heuristics for judging were utilized in one game, the ChamberBreaker game (Jeon et al., 2021). None of the games were designed to correct misconceptions caused by misinformation, and thus, reactive (debunking) game interventions were not identified.

### *Identified game design trends*

This section reports the game design trends we identified in the included games. Table 3 summarizes the game types, narrative approaches, learning mechanics, and feedback and incentive systems of the games. The games were digital with two exceptions (a card game and a board game). Based on the core learning mechanics and feedback systems, we classified nine games as simple choice-based simulations. The Escape the Fake game (Paraschivoiu et al., 2021) differed significantly from other games because it was an AR-based (augmented reality) escape room game. We identified two main game categories based on narrative approaches and related learning mechanics.

In the first category, the player adopts a role as a misinformation producer whose task is to create and spread misinformation as efficiently as possible. The main challenge is to spread misinformation to gain, for example, likes or followers in the simulated media channel while maintaining credibility. For example, in the Bad News game (Maertens et al., 2021), the player adopts the role of a fake news producer who aims to spread fake news to gain popularity and credibility as a news publisher. In the game, the player learns how several misinformation manipulation techniques can be used to produce credible fake news (the game aims to build resistance against these techniques). Most of the games of this category were simple choice-based simulations that included guided gameplay (e.g. Bad news, Harmony Square, Go Viral!, ChamberBreaker), and the consequences of choices were shown as changes in simulated metrics. Some of the metrics used (e.g. credibility, trust, and followers) were dynamic. We believe that the dynamic feedback channels are useful as they reflect the operation of social media systems better than cumulative metrics such as points. Moreover, two games, Bad news and Harmony Square awarded badges to players throughout the game when players had successfully mastered a misinformation manipulation technique. In these games, badges were used to emphasize the essential learning content of the game and provided mastery experiences to the players.

In the second category, the player adopts a role as a fact-checker whose task is to identify misinformation or fake news. For example, in the Trustme! Game (Yang et al., 2021), the player adopts the role of a famous influencer whose job is to help check the reliability of the information. In practice, the player judges online articles as reliable or unreliable. Also, in MathE the Game, the player acts as a fact inspector (Katsaounidou et al., 2019). This game differs from simple choice-based games. It supports players' work in identifying fake news by providing authentic verification tools such as search engines, reverse image search, image verification assistant, and debunking sites.

### *Study methods and overall outcomes*

In the reviewed papers, different research designs were realized (see Table 4). Eight out of 15 studies employed one or more control groups (e.g. active, passive control groups; different types of games),

**Table 3.** Game types, narrative approaches, core learning (game) mechanics, and the theoretical basis of games included in the reviewed papers.

| | Game | Game type | Narrative approach | Core learning (game) mechanics | Theoretical basis |
|---|---|---|---|---|---|
| 1 | Go Viral! | Choice-based simulation | Play as a social media influencer and spread misinformation about COVID-19 | Spread misinformation with social media posts, share social media content, and create a conspiracy theory | Likes and credibility points |
| 2 | ChamberBreaker | Choice-based simulation | Share biased tweets to form an echo chamber effect in SNS | Choose and share tweets in SNS community | Echo chamber & trust meter, grades, community tweets |
| 3 | Bad News | Choice-based simulation | Produce fake news to gain popularity and credibility as a news publisher | Spread fake news without losing credibility | Credibility metrics, followers |
| 4 | Escape the Fake | AR-based escape room adventure with quizzes | Save the world by recognizing fake news | Explore rooms, solve quizzes, and recognize fake news | |
| 5 | Trustme! | Choice-based simulation | Play as a famous influencer who has to help checking reliability of information | Judge reliability of online information | Progress, followers, points, elaborated feedback |
| 6 | Bad News | Choice-based simulation | Produce fake news to gain popularity and credibility as a news publisher | Spread fake news without losing credibility | Credibility metrics, followers, badges |
| 7 | FakeYou | Competitive multiplayer game | N/A | Create believable misleading headlines for news and identify fake headlines | Points |
| 8 | UNISON | Cooperative board game | N.A. | Solve quizzes and exploration tasks cooperatively | extra time |
| 9 | Bad News, Fakefinder | Choice-based simulation | N/A | Badnews: Spread fake news without losing credibility Fakefinder: Detect fake news | Credibility metrics, followers, badges |
| 10 | Harmony Square | Choice-based simulation | Play as a fake news producer to foment internal divisions in neighborhood | Spread misinformation to ruin the square's idyllic state | Likes, badges |
| 11 | Factitious | Multiple choice quiz (true or false) | Identify fake news | Judge articles either to real or fake | Points, correctness, knowledge on answers |
| 12 | MAthE the Game | N/A | Play as a fact inspector to identify fake news | Search engines, reverse image search, image verification assistant, and debunking sites to identify fake news | Points |
| 13 | Bad News | Choice-based simulation | Produce fake news to gain popularity and credibility as a news publisher | Spread fake news without losing credibility | Credibility metrics, followers, badges |
| 14 | Fake news game | Competitive card game | Create fake news that reflect goals and motivations of provided characters | Create believable fake articles from provided information pieces | Points |
| 15 | Bad News | Choice-based simulation | Produce fake news to create a successful fake news website | Spread fake news without losing credibility | Credibility metrics, followers |

while seven were based on a pre-posttest design. As regards the sample, only two studies tested the used game specifically on underaged participants. Paper 1 (Basol et al., 2021, p. 2 studies) and paper 3 (Maertens et al., 2021, p. 3 studies) included multiple studies. Overall, an average of 4386 participants were tested for each article (summing up all participants divided by the number of articles). However, four papers (Basol et al., 2021; Grace & Hone, 2019; Jeon et al., 2021; Roozenbeek & van

der Linden, 2019a) heavily skew the distribution because of very large sample sizes compared to the rest of the articles. Therefore, the median of participants across all articles (median = 196) better describes the conducted studies and reviewed articles. It is also noteworthy that in four articles, the participants were recruited through crowdsourcing platforms. The playing time of the games was reported in 11 papers. The median playing time in interventions was 15 min (Min = 5 min; Max = 30–120 min).

The reviewed studies used very different and diverse outcome metrics and measures. The assessed outcomes were often specifically adapted to the evaluated game and/or the approach. That is, specific assessments were developed to test the effects of the game. Thus, a more standardized way of measuring outcomes in the games designed to support critical reading skills might be a valuable future research opportunity. Nevertheless, all studies reported positive outcomes. However, it needs to be noted that 7 out of 15 studies did not use a control group. The effect sizes of studies that employed a pre-posttest design with a control group are reported in Table 4 (only statistically significant findings). In general, the effect sizes varied from small to large.

## Discussion

With the current systematic literature review, we aimed to provide a broad overview of empirical studies using games to tackle misinformation. We could only find 15 relevant papers for the review, questioning whether the documented trends and outcomes are representative. However, this is not particularly low compared to other recent systematic reviews on game-based learning and more specialized topics (see, e.g. Eichenberg & Schott, 2017; Ninaus & Nebel, 2021; Perttula et al., 2017). Regardless of the low sample, we found that most games utilized a choice-based simulation approach, dealt with fake news, were designed to build resistance to misinformation manipulation techniques, and based their approach on inoculation theory. Further, the applied methodology to examine the potential effects of the games was heterogeneous, but most studies reported positive outcomes. In the following, we will discuss the findings in greater detail.

### *Summary of main findings*

The current literature review revealed that the use of games in critical reading had emerged just recently, during the last three years. The emerging research efforts may stem from the increasing relevance of critical reading in our information society (Bråten & Braasch, 2017) and the recent radical increase in research on fake news (Xu et al., 2022). In comparison to other – more traditional – learning domains, such as STEM (Boyle et al., 2016; Hainey et al., 2016; Wouters et al., 2013), the use of games is still rare. These findings indicate that game-based critical reading research is still in its early phases. Nevertheless, as the amount of misinformation is growing, we firmly believe that the number of published papers focusing on games designed to support critical reading skills will further increase in the future. Already, in the time between conducting the systematic review and publication process, new studies on this topic have emerged (e.g. Hu et al., 2023; Modirrousta-Galian & Higham, 2023; Modirrousta-Galian et al., 2023; Neylan et al., 2023; Sureephong et al., 2023). This will warrant an update of the current systematic review in a few years' time.

The analysis of the games was challenging as several of the games were superficially described. Nevertheless, the analyses revealed that the reviewed games shared a lot of similar features. Maybe, the award-winning Bad News game, which was investigated in five of the reviewed papers, has inspired the design of other games.

Most games were based on inoculation theory (Compton et al., 2021; Ecker et al., 2022) and relied on a pre-emptive intervention approach. Several of these games were guided choice-based simulations. However, simulations and simulation games are very popular in the field of game-based

**Table 4.** Summary of samples, research designs, and main outcomes.

| Paper Id | Sample | Research design | Main outcomes |
|---|---|---|---|
| 1 | Study 1: n = 1771<br>Study 2: n = 1777<br>crowdsourcing adults | Study 1: Within-subject pre-posttest design; No control group<br>Study 2:<br>Between-subject pre-posttest design (+subsample 1 week follow-up);<br>Experimental group (game) vs. control group (Infographics) vs. control group (playing Tetris) | Increased perceived manipulativeness of misinformation (medium effect size);<br>Increased confidence in spotting misinformation (small effect size);<br>Experienced more motivational threat to defend their attitudes;<br>Reduced willingness to share misinformation with others (no longer after 1 week) |
| 2 | n = 882<br>crowdsourcing adults | Between subject pre-posttest design;<br>Experimental (game) vs. active control group (read explanation about echo chambers and examples of tweets used in the game of the experimental group) | Awareness of the echo chamber effect increased;<br>Intention to observe online information from more diverse perspectives increased (medium effect size);<br>Awareness of the echo chamber effect increased (small effect size) |
| 3 | Study 1: n = 151<br>Study 2: n = 194<br>Study 3: n = 170<br>Crowdsourcing adults | Between-subject Pre-posttest design;<br>Experimental group (game) vs. control group (Tetris playing) | Participants found fake news headlines significantly less reliable than before playing the game (medium to large effect sizes).<br>Check more detailed results about delayed tests from the paper. |
| 4 | n = 49<br>14–18 year old participants at a public event | Posttest only;<br>No control group | "High" flow ratings and concentration;<br>Perceived learning effectiveness not particularly high;<br>Well accepted game |
| 5 | n = 210<br>adults | Between-subject posttest only design;<br>Experimental group (game) vs. control group (quiz without game elements) vs. passive control group | Game increased information discernment skills but not skepticism towards online information |
| 6 | n = 196<br>crowdsourcing adults | Mixed pre-posttest design;<br>Experimental group (bad news game) vs. control group (tetris game) | Game improves the ability to spot misinformation techniques compared to a control group (medium effect size);<br>Increases the level of confidence in own judgments in individual-level (medium effect size) |
| 7 | n = 53<br>no age provided | Posttest only;<br>No control group | Descriptive outcomes only:<br>"Majority" of the participants perceived to have improved in their ability to detect fake/correct headlines;<br>31 of participants (58%) had fun creating headlines |
| 8 | n = 15<br>adults | Posttest only;<br>No control group | Descriptive outcomes only:<br>High level of overall satisfaction;<br>86% indicated to have learned something |
| 9 | n = 72<br>adults | Between-subject pre-posttest design;<br>Groups: fake news spreader game (bad news game) vs. fake news detection game (fakefinder game) | Fake news detection game increased participants' news classification score very modestly whereas the fake news spreader game did not improve the score at all. |
| 10 | n = 681<br>adults | Mixed pre-posttest design;<br>Experimental group (Harmony Square game) vs. control group (tetris game) | Experimental group found misinformation less reliable (medium effect size), were more confident to spot manipulative content (small effect size), and reported less likely to share misinformation (small effect size). |
| 11 | n = 45031<br><9 - 79 years of age | Data from an openly available online game;<br>No control group | Positive relation between fake news identification performance and age (until the approximate age of 70). Higher education correlated positively with performance. |
| 12 | n = 111<br>adults | Within-subject pre-posttest design;<br>No control group | Self-reported raised awareness on the misinformation phenomenon and debunking websites |

(*Continued*)

**Table 4.** Continued.

| Paper Id | Sample | Research design | Main outcomes |
|---|---|---|---|
| 13 | n = 14266<br><18 - 50 + years of age | Within-subject pre-posttest;<br>(In-game) design;<br>No control group | Gameplay improved ability to spot and resist misinformation, Irrespective of education, age, political ideology, and cognitive style |
| 14 | n = 95<br>underaged high school students | Between-subject posttest only design;<br>Experimental group (fake news game) vs. control group (unrelated presentation) | The treatment group rated the (fake news) article's reliability significantly lower than the control group. |
| 15 | n = 71<br>adult participants | Between subject pre-posttes design;<br>Experimental group (bad news game) vs. control group (text-based information) | Knowledge gain not significantly different between groups. Authors reported that the subjectively rated learning/knowledge gain was higher in game group – however, qualitative reporting was different from quantitative results (i.e. inconsistent reporting). |

Note. Only the effect sizes of studies that employed a pre-posttest design with a control group are reported in the Main outcomes column. Used effect size interpretation thresholds: Cohen's d: small = 0.2; medium = 0.5; large = 0.8. Partial eta squared: small = 0.01; medium = 0.06; large = 0.14.

learning in general (Boyle et al., 2016), and thus, this outcome might not be specific to games designed to support critical reading skills. Nevertheless, it seems that guided simulations can be easily aligned with the principles of inoculation theory.

In general, the pre-emptive intervention games helped players build resistance against commonly used misinformation manipulation techniques. On a practical level, pre-emptive game interventions are cost-effective as they can be used in various domains and contexts. It was surprising that although source characteristics play a crucial role in critical reading (Salmerón et al., 2020), sourcing was not emphasized in the games. Motivational game design aspects were also neglected. For example, motivational theories that are usually applied in game design (Krath et al., 2021) were not considered in any of the game descriptions. However, it is noteworthy that forewarning (motivational threat) is an essential mechanism of inoculation, and it is used to increase a desire to defend oneself from manipulation attacks (Van Der Linden, 2022). Moreover, the analyses revealed that common competence-oriented game design elements such as points, badges, and progress bars (Zainuddin et al., 2020) were used in several of the reviewed games. Moreover, the games also relied on stories. Misinformation producers and fact-checkers were the most common story frames of the games.

Over half of the conducted studies used at least one control group to examine the effects of the games. Importantly, several studies did use rigorous research designs (e.g. Basol et al., 2021; Maertens et al., 2021) and collected large samples (e.g. Grace & Hone, 2019; Roozenbeek & van der Linden, 2019a; Roozenbeekvan & der Linden, 2020) to investigate the effects of the games. These studies have the potential to act as exemplary research endeavors in this domain. High Field-Weighted Citation Impacts of the papers (Basol et al., 2021; Maertens et al., 2021; Roozenbeek & van der Linden, 2019a) indicate that these works have aroused interest in the research community. On the other hand, some studies focused on examining proof of concepts or design aspects of the games. Such studies emphasize the importance of interdisciplinary work in the game-based learning field. It was also surprising that most of the studies were targeted at adults. This is alarming, as previous research has shown that children and adolescents may struggle in critical reading (Hämäläinen et al., 2020; Kiili et al., 2017; Kiili et al., 2019).

Moreover, none of the studies or games were utilized as regular classroom activities in formal educational settings. Consequently, the gameplay was not integrated into other instructional activities. This is unfortunate because previous research has shown that integration usually increases the effectiveness of game-based learning (Wouters et al., 2013). We suggest that games designed to support critical reading skills should also be studied with younger participants and in formal educational settings.

The review also revealed that the assessed outcome variables varied tremendously across research studies (e.g. spot and resist misinformation; skepticism, awareness, perceived manipulativeness of misinformation) as the studies focused on the different content domains and approaches. Accordingly, the current review does not allow for drawing clear conclusions regarding the efficacy of games designed to support critical reading skills. However, as game-based learning has been previously shown to be an effective instructional approach (Sailer & Homner, 2020; Wouters et al., 2013), and all the reviewed studies reported positive effects, we cautiously consider game-based learning as a promising intervention approach in tackling misinformation (please note, however, the identified inconsistent reporting for paper 14; see Table 4). In any case, the research on games designed to support critical reading skills is not mature enough to make generalizations, and therefore, we call for more systematic research.

### *Limitations and threats to validity*

The findings of the present review are limited by publication forums indexed by Scopus, IEEE Xplore, APA PsycNet, and SAGE Journals databases. To address the possible negative effects of the used search terms and the databases, we also conducted a reference search. We screened 820 references that produced only three extra papers. This may indicate that despite using limited databases, we managed to include most of the relevant papers in the review. If the number of publications found with the reference search would have been large, it would have undermined the scientific value of the review. Nevertheless, it is still possible that we may have missed specific papers that should have been included in the review, but these papers are not widely cited, or the terms that were included in our search query were not used in those papers.

## Conclusions

The current systematic literature review provides a previously lacking overview of the use of game-based learning in the domain of critical reading. The critical reading domain received immense research interest recently due to the rise of fake news and misinformation. In line with this, the current review identified a surge of game-based approaches to foster critical reading in the last three years. Despite this surge, we found a relatively small number of empirical studies in the current literature review. However, we firmly believe that publications in this domain will increase significantly in the future.

Most of the games were grounded on inoculation theory and consequently designed to expose players to weakened doses of misinformation manipulation techniques to build resistance against them. While some of the conducted studies employed rigorous research designs, there was large variability in research designs and assessed variables. This, together with the overall low number of studies, makes it difficult to derive clear and representative conclusions about the efficacy of games designed to support critical reading skills. Nevertheless, it needs to be noted that all reviewed studies reported positive effects.

Furthermore, when analysing game design trends, it became apparent that descriptions of used game mechanics and elements are incoherent. Therefore, a standardized way of describing games needs to be developed and deployed to allow a more systematic comparison between games and game design elements. To conclude, the research on game-based learning in the critical reading domain is still in its infancy and requires more systematic research like other domains of game-based learning.

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