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# Learning to Evaluate (Mis)information in an Online Game: Strategies Matter!

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ABSTRACT

Digital games can help students learn how to cope with misinformation. However, misinformation games typically include multiple game mechanics, making it hard to identify which mechanics contribute to learning. Hence, the aim of this study was to clarify how misinformation games promote learning by examining the effects of two promising misinformation game mechanics– simulating evaluation strategies and providing explanations about the types of misinformation encountered in the game. The participants were 132 8th and 9th-grade students who played different versions of a misinformation game that either simulated evaluation strategies or did not simulate them and either included misinformation explanations or did not include them. The results indicated that simulating evaluation strategies improved sharing and accuracy discernment following the game, but providing misinformation explanations did not. Simulating evaluation strategies also led to greater awareness of corroboration and sourcing strategies, whereas misinformation explanations only supported awareness of sourcing. Structural equation modeling revealed that simulating evaluation strategies led to more accurate sharing decisions in the game and that in-game sharing accuracy mediated the effect of simulating strategies on post-game accuracy and sharing discernment. These findings advance the understanding of misinformation game design by identifying game mechanics that are conducive to learning. The findings highlight that simulating evaluation strategies in a game can help prepare learners to cope with misinformation. More research is needed to explore the effective integration of misinformation explanations into such games.

## 1. Introduction

In an era marked by the rapid flow of information across digital platforms, the spread of misinformation has become a critical societal concern. Misinformation, which can be broadly defined as “any information that is demonstrably false or otherwise misleading” (APA, 2023, p. 7), may erode trust in public institutions and potentially undermine informed decision-making by citizens and public policymakers (Kozyreva et al., 2020; Lewandowsky et al., 2017). The ubiquitous nature of online misinformation has motivated efforts to develop effective interventions for reducing its harmful effects (reviewed by Kozyreva et al., 2024; Ziemer & Rothmund, 2024).

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Digital games are promising tools for disseminating misinformation interventions at scale (European Commission, 2022; Kiili et al., 2024). Learning games include game mechanics that translate learning practices or goals into gameplay elements which are related to players' actions (Arnab et al., 2015). Similarly, misinformation games include game mechanics that *translate misinformation interventions into elements of gameplay*. While previous studies have generally shown the benefits of playing misinformation games, these games typically include multiple game mechanics (Kiili et al., 2024). This makes it difficult to pinpoint which specific mechanics contribute to enhancing players' competence. Thus, a major challenge facing the field is to identify effective misinformation game mechanics that can be used to design impactful games. To address this challenge, there is a need for studies with value-added designs (Clark et al., 2016; Mayer, 2016) that examine the effects of adding specific features to a base version of the game. Accordingly, the goal of this study was to clarify the contribution of misinformation game mechanics by investigating how adding these mechanics to a misinformation game affects players' competence to evaluate online (mis)information and to share it responsibly.

The study focuses on two promising misinformation game mechanics – simulating evaluation strategies and providing explanations about the types of misinformation encountered in the game. Both game mechanics are based on misinformation interventions that have a robust psychological and empirical basis (Kozyreva et al., 2024). The first game mechanic is grounded in misinformation interventions that teach people how to use effective strategies for evaluating online information (Osborne et al., 2022; Wineburg et al., 2022). The second game mechanic is based on interventions that aim to inoculate people against recurring types of misleading communication (Lewandowsky & van der Linden, 2021; Traberg et al., 2022). These game mechanics also reflect predominant approaches to misinformation game design and have been employed in multiple misinformation games (Barzilai et al., 2023; Kiili et al., 2024; Roozenbeek & van der Linden, 2019, 2020; Yang et al., 2024; Yang et al., 2021). However, their precise contribution to players' competence is not well understood.

### 1.1. *Fostering resilience against misinformation*

In a recent review, Kozyreva et al. (2024) identified nine types of individual-level interventions against online misinformation that were classified into three categories: (1) nudges, which are aimed at improving decision-making processes by shaping behavior (e.g., accuracy prompts); (2) refutation strategies, which are aimed at refuting or correcting beliefs in misinformation (e.g., debunking and fact-checking labels); and (3) boosts and educational interventions, which are aimed at fostering competencies to check and identify misinformation. Boosts and educational interventions are especially relevant for schools because they focus on cultivating competencies to prepare learners for future encounters with misinformation. Two effective types of interventions in this category, which have been supported by diverse evidence, are teaching verification strategies for evaluating online information and inoculation against common forms of misinformation and manipulation (Kozyreva et al., 2024).

Cultivating verification strategies for evaluating online information can help learners discern between inaccurate and accurate information online (Osborne et al., 2022; Wineburg et al., 2022). Reliable evaluation strategies are strategies that have a better *likelihood* of achieving epistemic aims, even if their outcomes cannot be guaranteed (Chinn et al., 2014). For example, evaluating source trustworthiness by searching for information about the source is a more reliable strategy for judging the accuracy of online information than relying on visual design cues (Wineburg & McGrew, 2019). The SIFT model describes four strategies that can help people reliably evaluate online information (Caulfield, 2017; Caulfield & Wineburg, 2023): **S**topping to think about what you know about the claim and the source and whether you need to check them before reading further or sharing; **I**nvestigating the source by searching for information about it online (i.e., "lateral reading," Wineburg & McGrew, 2019); **F**inding out if other trustworthy sources also cover the claim or information (i.e., corroboration); and **T**racing the claim, quote, or media to the original context to find if it is reputable and accurately represented. Recent interventions have demonstrated that students can learn how to use these strategies (e.g., Hämäläinen et al., 2023; McGrew, 2024; Wineburg et al., 2022). These interventions typically employ instructional methods such as modeling or exemplifying how to use evaluation strategies and providing practice opportunities (e.g., Bråten et al., 2019; McGrew, 2020).

Another type of competence-building intervention is inoculation, which involves forewarning people against common misinformation and misleading communication techniques (e.g., Basol et al., 2020; Cook et al., 2017; Cook et al., 2023). These interventions are grounded in psychological inoculation theory, which posits, in a nutshell, that preemptively warning people against attempts to mislead and providing them with tools to refute such attempts can help protect people against misinformation (Compton et al., 2021; Traberg et al., 2022). Inoculation has been found to reduce the acceptance of information that employs the same misleading communication techniques that were learned (Lewandowsky & van der Linden, 2021; Traberg et al., 2022). However, inoculation may sometimes also decrease the perceived credibility of accurate information (e.g., Roozenbeek et al., 2022), perhaps because it can broadly increase skepticism and vigilance against online information (Modirrousta-Galian & Higham, 2023).

### 1.2. *Games against misinformation*

Digital games have the potential to foster resilience against misinformation (European Commission, 2022; Kiili et al., 2024). Some of the advantages of digital games are that they are easily scalable across settings, can support skill development and grasp of complex issues and problems, and can provide enjoyable learning opportunities that enhance learners' motivation (Barz et al., 2024; Mao et al., 2022; Plass et al., 2015). The use of digital games for learning needs to be weighed against the potentially adverse effects of intensive gaming and screen use on the health and well-being of children and adolescents (Faust & Prochaska, 2018; Melo et al., 2020). Misinformation games typically have short durations and provide opportunities for players to reason and reflect on critical real-world problems, which could positively contribute to their well-being. Indeed, a recent review found that playing misinformation games has generally favorable effects on players' critical competencies (Kiili et al., 2024). The aim of this study was to clarify how misinformation games work by examining the contribution of two recurring game mechanics: simulating evaluation strategies and providing explanations about various types of misinformation.

### 1.2.1. Using games to simulate evaluation strategies

Games can be effective tools for developing players' strategies. At their core, games engage players in solving a series of problems that require developing novel problem-solving strategies (Gee, 2005, 2007; Plass et al., 2015). Games can also support strategy acquisition by simulating how strategies can be used to solve problems. Such simulations can provide learners with a model of how these strategies are used across meaningful contexts. Modeling is a form of cognitive apprenticeship in which novices learn novel skills by observing how experts, teachers, or advanced peers perform these skills (Collins et al., 1989). As Collins (1988) has noted, modeling can also be provided by computer systems; for example, learners can learn from observing multimedia representations of problem-solving processes. Games can model processes and skills by "showing which information is important in order to solve a problem and how to solve a problem" (Wouters & van Oostendorp, 2017, p. 10). Modeling has been found to be an effective instructional technique for enhancing learning in games (Wouters, 2017). In addition to learning by observing a model, games also allow players to interact with the simulation. Interactivity can increase cognitive engagement and support organization and integration of information with prior knowledge (Moreno & Mayer, 2005).

Various misinformation games focus on introducing strategies for evaluating online information. In such games, the player's role is typically to fact-check incoming information (e.g., Grace & Hone, 2019; Yang et al., 2024). To help players achieve this objective, these games may provide interactive simulations of evaluation strategies that model how strategies are used and enable players to use strategies to solve evaluation problems (Barzilai et al., 2023; Yang et al., 2024; Yang et al., 2021). Evaluation games can also provide tools or hints that guide players on how to use evaluation strategies and feedback on judgment accuracy (Micallef et al., 2021; Yang et al., 2021). Initial findings suggest that playing such games can improve players' capabilities to evaluate information after the game (Barzilai et al., 2023; Yang et al., 2024; Yang et al., 2021).

For example, in the *Misinformation Is Contagious* game (Barzilai et al., 2023), learners are tasked with solving a consequential problem: whether or not to share social media messages about a raging epidemic with their followers while being aware of the risks of sharing inaccurate information. To solve this problem, players are provided with three tools that represent reliable evaluation strategies based on the SIFT model, see Fig. 1. For example, players can select "Who is the source?" to learn more about the message's source. After clicking on a strategy, players can read a short description of how the strategy was used and what was learned by using the strategy (e.g., "You searched for information about the "Healthy Consumers" organization in Wikipedia and in some other sites. You discovered that the organization is against using new technologies that emit radiation such as cellular and wireless networks"); see Fig. 2. This demonstrates how the strategy can be used to find information that can help evaluate the source. Each message can be checked in this manner using each of the three strategies to demonstrate the variety of available strategies and how they sometimes need to be combined to form a reasonable judgment. Thus, by interacting with the game, players can observe examples of how evaluation strategies are used in context and can experience how these strategies help judge the accuracy of social media messages. Players are encouraged to take an active role by selecting strategies and making sharing decisions based on what they learned.

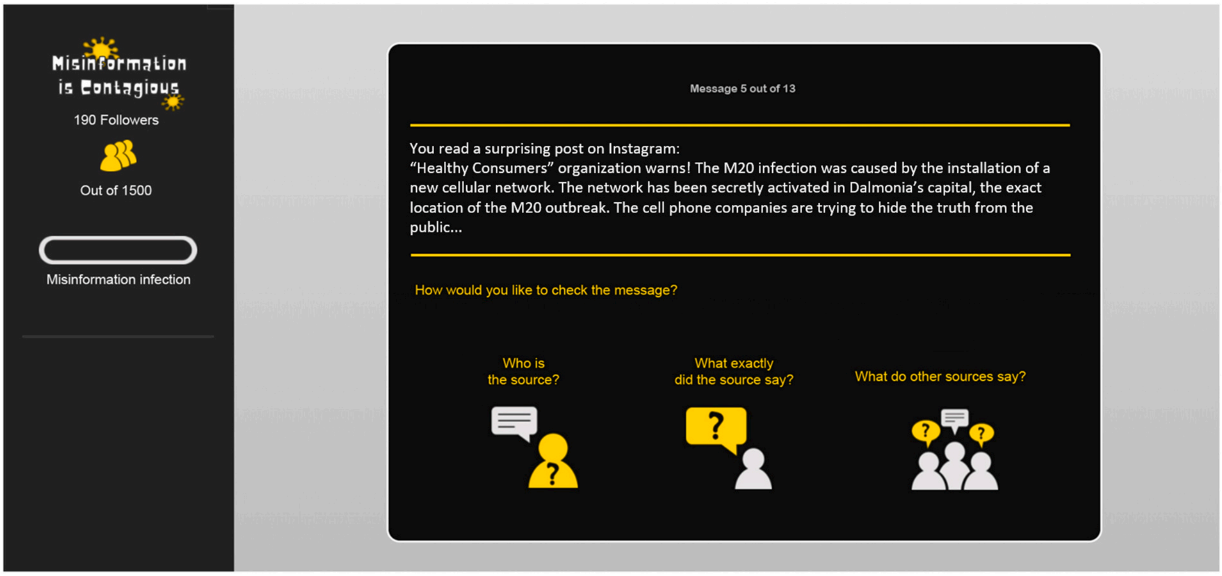


**Fig. 1.** Message evaluation screen with evaluation strategy tools

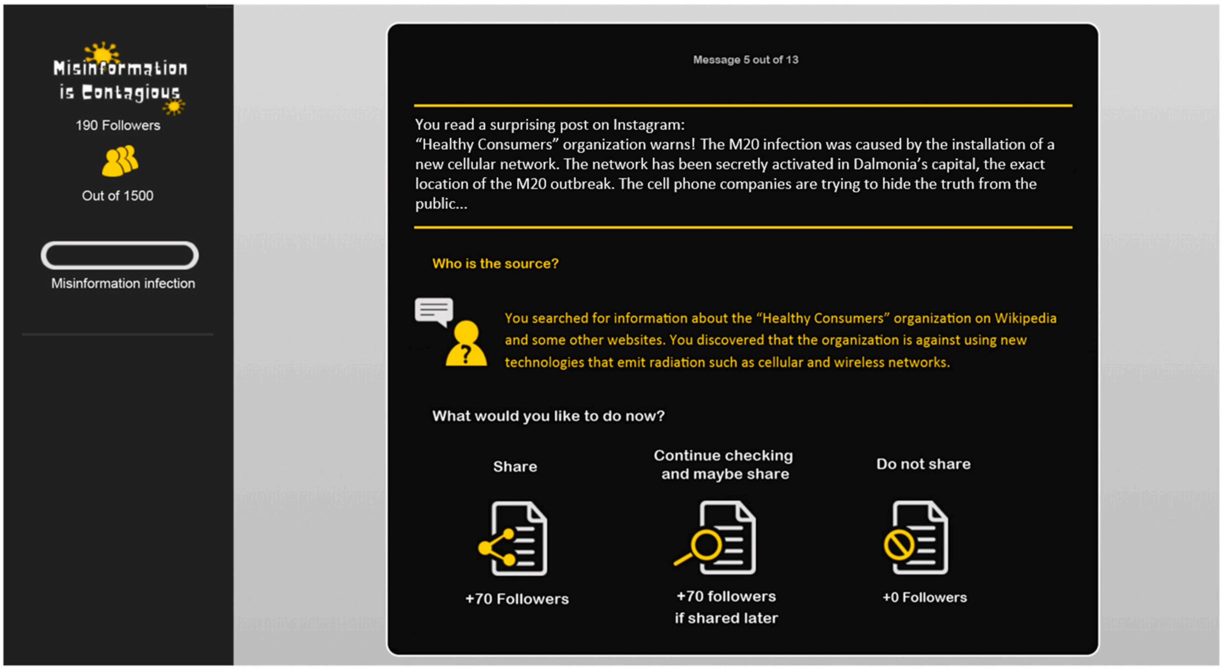


**Fig. 2.** Message evaluation screen after choosing an evaluation strategy

Simulating evaluation strategies in this manner could support players' competence in several ways. First, observing and experiencing how evaluation strategies are used could enhance players' cognitive abilities to use these strategies. Hypothetically, the more opportunities players have for seeing how strategies can be used to effectively judge information in the game, the more successful they might be in using these strategies outside the game. Second, interacting with evaluation strategies in the game may help players achieve better game outcomes and a higher game score. This could strengthen their motivation to evaluate information in the future. Third, simulating evaluation strategies could help develop players' metacognitive knowledge about these strategies, or, in other words, their metastrategic knowledge (Kuhn & Pearsall, 1998; Zohar & Ben David, 2009). More specifically, labeling the strategies can support knowing *what* strategies can help solve the problem; choice among strategies can encourage players to consider *when* each of the strategies should be used; and observing how the strategies are applied could foster understanding of *how* to use the strategies and *why* they are valuable. Fostering metastrategic knowledge can increase the likelihood that strategies will be effectively used in future contexts (Dignath & Veenman, 2021; Zohar & Peled, 2008).

In a previous study, we found that playing the *Misinformation Is Contagious* game indeed resulted in greater metastrategic knowledge about evaluation strategies, particularly about corroboration, compared to an active control group that played a language game (Barzilai et al., 2023). Players of the *Misinformation Is Contagious* game also exhibited better accuracy and sharing discernment. However, that study tested the effects of the game as a whole, as is typically done in the first stages of testing a novel learning game. Hence, it is unclear if and how simulating evaluation strategies in the game contributed to learners' performance over and beyond other game elements, such as engaging in evaluation of (in)accurate social media messages and receiving feedback on evaluation outcomes.

*1.2.2. Using games to explain misleading communication*

Another misinformation game design approach focuses on inoculating players against common misinformation techniques (e.g., Cook et al., 2023; Roozenbeek & van der Linden, 2019). Inoculation games employ various misinformation game mechanics that aim to create resistance against misinformation, such as tasking players with identifying or using misleading communication techniques, providing just-in-time explanations about these techniques (e.g., "Emotional content can be extremely effective if you want your news to go viral", Roozenbeek & van der Linden, 2019), and earning badges that label the techniques (e.g., Basol et al., 2020; Cook et al., 2023). Inoculation games have been found to lower the perceived credibility of unreliable information that employs the same misleading communication techniques that were learned in the game among adults (Maertens et al., 2021; Roozenbeek et al., 2022) as well as among upper secondary school students (Axelsson et al., 2024).

In the present study, we focused on examining the contribution of a specific inoculation game mechanic: providing players with retroactive explanations about the misinformation they encountered in the game. This game mechanic is a type of "experiential inoculation" (Trecek-King & Cook, 2024): Players first experience (and sometimes fall for) misinformation and are then provided with an explanation about the misinformation that they experienced. For example, in the *Misinformation Is Contagious* game (Barzilai et al., 2023), players encounter various types of misinformation, such as fake news, impersonation, or conspiracy theories. After making a sharing decision, players learn what kind of misinformation they encountered and receive a short explanation about how it misleads;

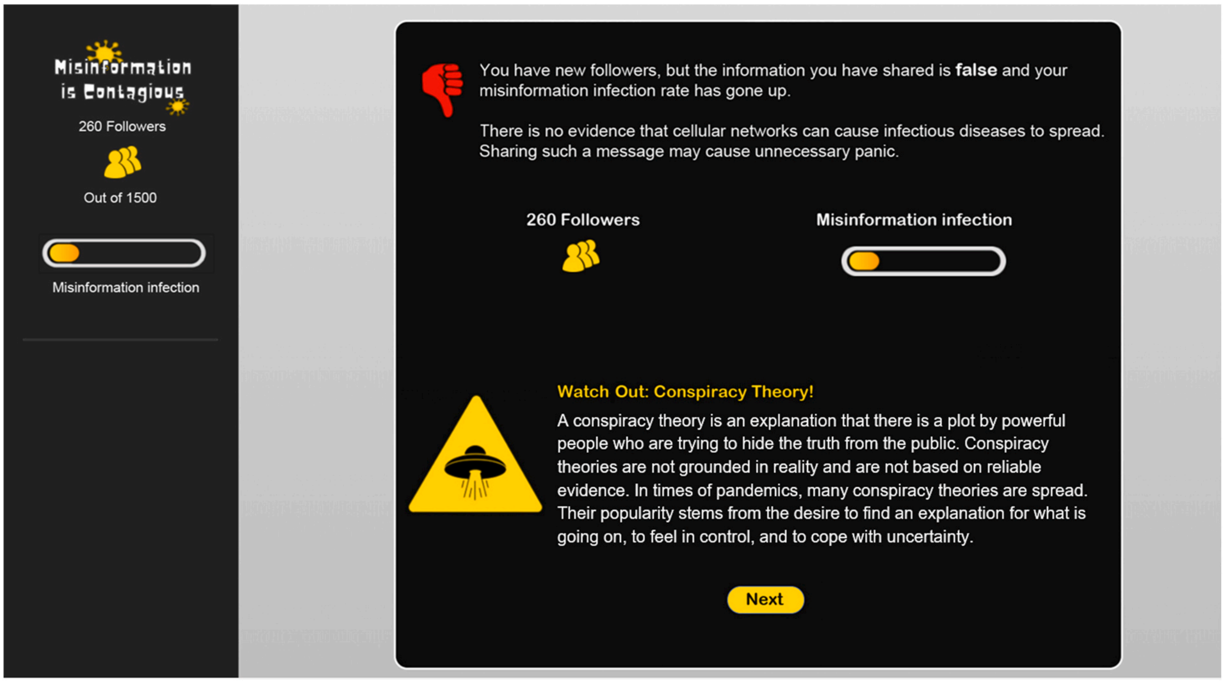


**Fig. 3.** Feedback screen with misinformation explanation

see example in Fig. 3.

Based on inoculation theory, such explanations may contribute to fostering players' resilience against misinformation in two ways. First, the experience of (almost) being fooled can motivate future resistance against misinformation (Traberg et al., 2022; Trecek-King & Cook, 2024). Second, providing information about why this misinformation misleads may promote players' awareness of what to watch out for and provide them with tools for refuting future attempts to misinform (Traberg et al., 2022). This inoculation effect could hypothetically result in better evaluation and sharing performance both in and after the game.

Providing explicit explanations could also potentially help address one of the limitations of game-based learning: Because game-based learning is highly situated, players' understandings may be intuitive and tacit, and they might not grasp the broader connections of the concepts introduced by the game (Barzilai & Blau, 2014; Clark & Martinez-Garza, 2012). Misinformation explanations might help players develop more abstract and generalized understandings of the examples of misinformation they encountered. This could potentially support the transfer of these concepts to novel encounters with misinformation. However, to our knowledge, the added value of including such explanations in misinformation games has yet to be tested.

### *1.3. Research questions*

Previous studies have generally shown that digital misinformation games can help foster players' competencies (Kiili et al., 2024; Traberg et al., 2022); however, because these games typically include multiple game mechanics, we still know little about which elements contribute to learning from misinformation games. Hence, the goals of this study were to experimentally examine two emerging misinformation game mechanics in order to clarify whether and how they support players' competencies to cope with misinformation. Specifically, we focused on examining the effects of simulating evaluation strategies in the game and providing players with explanations about the types of misinformation they encountered in the game. The following research questions and conjectures guided the study.

1. *How does simulating evaluation strategies in a misinformation game contribute to post-game performance?* Teaching reliable evaluation strategies may enhance learners' capabilities to judge (in)accurate information (e.g., Hämäläinen et al., 2023; McGrew, 2024). Hence, we conjectured that simulating strategies in the game would lead to better sharing discernment and accuracy discernment between inaccurate and accurate information after the game. We also conjectured that simulating evaluation strategies would enhance players' metastrategic knowledge about evaluation strategies, particularly knowledge about corroboration (Barzilai et al., 2023).

2. *How does providing misinformation explanations in a misinformation game contribute to post-game performance?* Providing explanations about misinformation may help forewarn against misinformation (Traberg et al., 2022; Trecek-King & Cook, 2024) and could help players abstract their intuitive understandings of the game (cf. Barzilai & Blau, 2014; Clark & Martinez-Garza, 2012). Therefore, we conjectured that adding misinformation explanations to the game would result in better sharing discernment and accuracy discernment. We did not have specific conjectures regarding the effects of misinformation explanations on metastrategic knowledge. Nonetheless, we considered the possibility that these explanations could heighten awareness of the need to employ evaluation strategies.

3. *Does in-game performance mediate the effect of simulating evaluation strategies and misinformation explanations on post-game performance?* We conjectured that simulating evaluation strategies and providing misinformation explanations would improve players' capabilities to evaluate and share information in the game. In turn, players' in-game performance would predict their accuracy discernment and sharing discernment after the game.

As individual difference variables, we considered students' topic knowledge and topic interest because these factors may influence the evaluation of sources and information (Anmarkrud et al., 2022). We also considered players' news consumption habits due to their potential effects on evaluation skills (Nygren & Guath, 2022).

## 2. Method

### 2.1. Participants and design

The participants included 8th and 9th-grade students recruited from three comprehensive public secondary schools in Israel. The study received ethical approval from a university ethics committee and required informed consent. We invited entire classes to participate in the study based on their teachers' willingness to conduct the study during their lessons. Students volunteered to participate in the study and did not receive any incentives.

The sample size was determined based on a power analysis assuming medium effect sizes (Barzilai et al., 2023), an alpha error probability of .05, and .80 power (Faul et al., 2007). The analysis indicated that a minimum sample size of 128 was needed. Therefore, we collected 157 responses from students who completed the game and the post-game sharing intentions and accuracy judgment measures. However, consistent with the procedure of our previous study (Barzilai et al., 2023), we excluded 25 participants who failed an attention check question, gave identical responses to all the sharing discernment and accuracy discernment items, or did not perform the study independently. The final sample included 132 participants. The mean age of the participants was 14.23 years ($SD =$ 0.70), and they included 52.4% boys, 40.3% girls, 4.8% other genders, and 2.4% who preferred not to state their gender.

To test the effects of simulating evaluation strategies and providing misinformation explanations, we employed a 2X2 between-subjects factorial design. Half of the participants were randomly assigned to play a version of the game that simulated evaluation strategies, and half played a version without strategies (strategies factor). Additionally, half of the participants were randomly assigned to play a version of the game with misinformation explanations and half did not receive explanations (explanations factor).

### 2.2. Materials

All participants played the *Misinformation Is Contagious* game[1]. The game's objective is to increase the player's number of followers without spreading misinformation. In the game, players read various accurate and inaccurate messages about a fictitious pandemic caused by a mysterious illness and must decide whether to share them. After sharing a message, players receive feedback regarding its accuracy, the number of new followers, and whether their followers were "infected" with misinformation. This design is intended to foster awareness of the impact of spreading misinformation and to cultivate responsible sharing dispositions.

In this study, players were randomly assigned to play one of four game versions, see Fig. 4. In the *control condition*, players read the messages, decided whether to share them, and then received simple feedback regarding the accuracy of the messages and the effects of sharing them on their followers. In the *strategy condition*, participants had the option to check the message before sharing and could utilize up to three evaluation strategies based on the SIFT model (Caulfield & Wineburg, 2023) and the COR curriculum (Wineburg et al., 2022), see Fig. 1: (1) source evaluation through "lateral reading" ("Who is the source?"); (2) corroboration using trustworthy sources, such as science, health, or news sources ("What do other sources say?"); and (3) tracing the original context to see if the information is accurately presented and not taken out of context ("What exactly did the source say?"). In the *explanation condition*, participants did not receive strategies. However, after making a sharing decision, they could read a brief explanation about the type of misinformation they had encountered, as illustrated in Fig. 3. These explanations included the name of the misinformation type (e.g., "Conspiracy Theory") as well as a brief description of the misinformation and how it misleads. The explanations are provided in Table S1 in the Supplementary Material. Finally, in the *strategy + explanation condition*, participants could check the messages using the three strategies and also received explanations about the type of misinformation they had encountered.

[1] The game is openly available online at https://fakenews-game.edu.haifa.ac.il/.

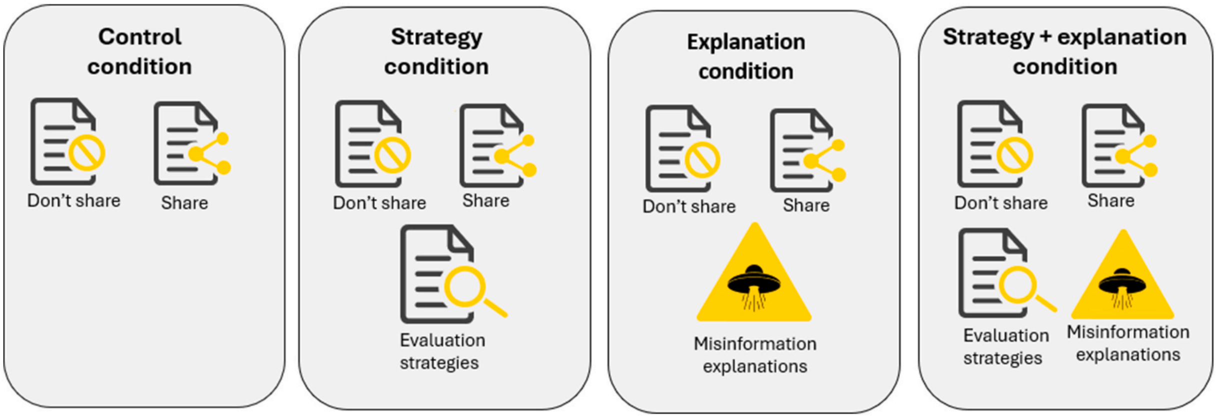


**Fig. 4.** Experimental conditions

### 2.3. In-game and post-game measures

***In-Game Sharing Accuracy***. The game included thirteen messages that participants could potentially share. We collected the sharing data and computed a sharing accuracy score by assigning a single point to every accurate message that was shared and every inaccurate message that was not shared.

***Checking Messages in the Game.*** To gauge engagement with the game, in the strategy and strategy + explanation conditions, we also tracked the number of messages that participants checked using the evaluation strategies.

***Post-Game Sharing Discernment.*** In line with current practices for studying the outcomes of misinformation interventions (Guay et al., 2023; Kozyreva et al., 2024), we used sharing discernment as one of our primary outcomes. Sharing discernment represents the extent to which participants express intentions to share true relative to false content (Guay et al., 2023). Sharing decisions can be shaped by diverse factors, including perceptions of the accuracy, relevance, and interestingness of the messages, perceived source credibility, who shared and liked the message, sharing habits, and sharing motivations (Altay et al., 2022; Ceylan et al., 2023; Herrero-Diz et al., 2020; Kümpel et al., 2015). The sharing discernment measure specifically focused on assessing the effects of message accuracy and source reliability on intentions to share. Participants read 14 messages about COVID-19 and were asked to indicate the likelihood that they would share these messages on a seven-point scale to capture nuanced differences in the strength of their sharing intentions. Eight of the messages were based on authentic COVID-19 misinformation, identified by fact-checkers, and the remaining messages included accurate information. The sources of the inaccurate messages were social media sources or unfamiliar websites; whereas the sources of the accurate messages were reputable scientific or news organizations. The inaccurate items contained hints of conspiratorial thinking, impersonation, and pseudo-science and ranged from half-truths to utter fake news. The measure's design was intended to assess students' tendencies to critically question claims and sources and discern between reliable and unreliable ones. We did not ask students to verify the messages through online search because we wished to minimize and control students' exposure to COVID-19 misinformation due to the potentially harmful impact of such misinformation. The items are available in Table S2 in the Supplementary Material. The presentation order of the items was randomized. The internal consistency reliability of the inaccurate and accurate messages was $\alpha = .87$ and .88, respectively. We computed a sharing discernment score by subtracting the mean rating of the inaccurate items from the mean rating of the accurate ones (similar to the procedure of Basol et al., 2021). In line with Guay et al. (2023)'s two-step approach, we followed this analysis by separately examining the effects on the inaccurate and accurate items to understand how the game impacted discernment.

***Post-Game Accuracy Discernment.*** Participants next rated the accuracy of the same messages on a seven-point scale. The items were once again presented in random order. The internal consistency reliability of the inaccurate and accurate items was $\alpha = .84$ and .81, respectively. The accuracy discernment score was the difference between the mean ratings of the accurate and inaccurate items. This score represents the extent to which participants believe true relative to false content. In the second step, we also separately examined the effects on the inaccurate and accurate items (Guay et al., 2023).

***Metastrategic Knowledge About Evaluation Strategies.*** Participants were asked to describe in writing all the strategies they were familiar with for identifying COVID-19 misinformation ("How can misinformation about the coronavirus be identified, in your opinion? Please describe all the ways you are familiar with"). The prompt was broadly phrased to address participants' general awareness of evaluation strategies. The responses were coded using a coding scheme developed and validated by Barzilai et al. (2023). The coding scheme identified four recurring evaluation strategies in participants' responses: source evaluation, content evaluation, corroboration, and consultation with other people. The interrater reliability of the coding scheme was tested in our previous study and was found to be adequate (Cohen's Kappa .71 to 1.00). The coding scheme successfully captured the range of responses in the present study, so we did not alter it. Table S3 in the Supplementary Material includes the code definitions and representative quotations from the present study. Students often mentioned multiple strategies, so we computed a sum score of the total number of strategies each participant mentioned.

### 2.4. Individual difference measures

We measured several variables that can play a role in information evaluation.

**Topic Knowledge**. This measure assessed students' knowledge about COVID-19. Because both perceived and actual knowledge can play a role in evaluation (Anmarkrud et al., 2022), the measure included one perceived knowledge item that was rated on a seven-point scale ("How would you rate your knowledge level about the corona disease?"), as well as seven multiple-choice questions about COVID-19 that were adapted from a measure by Amit Aharon et al. (2021) (e.g., "Which of the following can protect you from contracting the corona disease?"). These multiple-choice questions addressed diverse areas of knowledge, such as risk groups, protective behaviors, vaccine effectiveness, and the nature of viruses. A topic knowledge score was computed by averaging the perceived knowledge rating and the number of correctly answered multiple-choice questions.

**Topic Interest**. Participants rated their interest in information or news about COVID-19 using a single item with a seven-point scale.

**News Consumption and Sharing**. News consumption habits may shape evaluation skills (Nygren & Guath, 2022). Hence, we also asked students how often they view or share information about COVID-19 or encounter misinformation about this topic, ranging from "never" to "several times a day."

### 2.5. Procedure

The study was conducted at school using an online survey platform. Students were first randomly assigned to play one of the four game versions that were embedded in the survey. To continue the survey, they were asked to enter a code that appeared on the final screen of the game to confirm that they had played the entire game (Basol et al., 2020). Participants then responded to the sharing discernment measure, accuracy discernment measure, metastrategic knowledge prompt, news consumption and sharing measure, topic interest question, and topic knowledge measure, in that order. Participants also responded to a pilot measure that was presented toward the end of the survey. Lastly, participants were debriefed and informed which of the messages that they read in the survey were accurate.

### 2.6. Data analysis

We first screened the dataset for missing data. Eight participants (6.1%) did not respond to the topic interest and news consumption measures, and twelve participants (9.1%) did not respond to the topic knowledge measure. The missing data were distributed among all four conditions, and Little's MCAR test was not significant, suggesting that the data were probably missing completely at random. We imputed the missing topic interest and topic knowledge scores using the expectation-maximization (EM) method in SPSS 27. Next, we screened the data for normality at the group level. The continuous variables were approximately normally distributed, except for the accuracy judgments of the inaccurate messages in one of the groups. Hence, we log-transformed this variable, which resulted in acceptable skewness and kurtosis values.

We used two-way ANCOVAs, controlling for topic knowledge and topic interest, to examine the effects of simulating evaluation strategies and providing misinformation explanations on our primary outcome variables because this was a statistically parsimonious analysis approach that controlled for impactful covariates (see Section 3.1). Before running ANCOVAs, we ascertained that the assumption of homogeneity of slopes was met. We used binary logistic regressions to examine the effects of the independent variables on metastrategic knowledge about specific evaluation strategies because these variables had a binary distribution. Finally, we used a structural equation model to analyze the mediating role of in-game performance, as this approach could comprehensively account for the interrelations among the independent and dependent variables.

## 3. Results

### 3.1. Preliminary analyses

To examine the equivalence of the groups, we conducted two-way ANOVAs on the topic knowledge and interest scores. Unexpectedly, the ANOVA on the topic knowledge score indicated that students who received explanations scored lower than students who did not receive explanations, $F(1,132) = 15.38$, $p < .001$, $\eta_p^2 = .11$ ($M = 3.70$, $SD = 0.98$ vs. $M = 4.36$, $SD = 0.94$). Similarly, the ANOVA on the topic interest scores indicated that students who received explanations reported lower interest than students who did not receive explanations, $F(1,132) = 4.05$, $p = .046$, $\eta_p^2 = .03$ ($M = 2.80$, $SD = 1.43$ vs. $M = 3.34$, $SD = 1.75$). No further effects on topic knowledge and interest were found. Considering these differences, we controlled for participants' topic knowledge and interest scores when analyzing the effects of misinformation explanations on the dependent variables. Generalized linear models indicated that there were no statistically significant differences between groups in age ($p \geq .969$), gender ($p \geq .644$), or COVID-19 information consumption and sharing (all items $ps \geq .355$). The Supplementary Material includes more information on participants' backgrounds (Table S4) and descriptive statistics of the dependent variables in the entire sample (Table S5).

As an indicator of engagement with the game, we examined the number of messages that students in the strategy conditions checked during the game. The students checked an average of 6.77 messages out of 13 ($SD = 4.29$), indicating that they frequently interacted with the strategies. There was no significant difference in the number of messages checked in the strategy and strategy + explanation conditions, $t(63) = 0.57$, $p = .569$, $d = 0.14$.

### 3.2. Effects on sharing discernment

A two-way ANCOVA on the sharing discernment score, controlling for topic knowledge and interest, revealed a statistically significant effect of simulating evaluation strategies on sharing discernment, $F(1,132) = 5.23$, $p = .024$, $\eta_p^2 = .04$, indicating that players who received the strategies outperformed players who did not receive them ($M = 2.01$, $SD = 1.83$ vs. $M = 1.29$, $SD = 1.85$). The effects of providing explanations and the strategies × explanations interaction were not significant, $Fs \leq 1.72$, $ps \geq .192$.

To better understand how simulating evaluation strategies impacted sharing discernment, we conducted separate independent sample t-tests on the mean ratings of the accurate and inaccurate messages (Guay et al., 2023). We found that simulating evaluation strategies resulted in greater intentions to share the *accurate* items with a medium effect size, $t(130) = 2.28$, $p = .024$, $d = 0.40$, $M = 4.57$, $SD = 1.60$ vs. $M = 3.92$, $SD = 1.66$. However, the effect on the *inaccurate* items was not significant, $t(130) = 0.29$, $p = .771$, $d = 0.05$, $M = 2.56$, $SD = 1.36$ vs. $M = 2.63$, $SD = 1.36$.

### 3.3. Effects on accuracy discernment

A similar two-way ANCOVA on the accuracy discernment score also revealed a statistically significant effect of simulating evaluation strategies, $F(1,132) = 4.25$, $p = .041$, $\eta_p^2 = .03$, indicating that players who received the strategies outperformed players who did not receive them ($M = 2.41$, $SD = 1.71$ vs. $M = 1.85$, $SD = 1.74$). Providing misinformation explanations had no significant effect, and neither did the strategies × explanations interaction, $Fs \leq 2.45$, $ps \geq .120$.

Similar to the effects on sharing intentions, independent sample t-tests indicated that players who were exposed to the strategies perceived the *accurate* items as more correct than players who did not receive the strategies, $t(130) = 2.79$, $p = .006$, $d = 0.49$, $M = 5.16$, $SD = 1.16$ vs. $M = 4.53$, $SD = 1.41$. In contrast, the effect on the *inaccurate* items was not significant, $t(130) = 0.54$, $p = .589$, $d = 0.09$, $M = 2.76$, $SD = 1.17$ vs. $M = 2.69$, $SD = 1.37$.

### 3.4. Effects on metastrategic knowledge about evaluation strategies

Source evaluation was the most frequent evaluation strategy mentioned by the students (67.4% of the entire sample), followed by corroboration (27.3%), content evaluation (23.5%), and consultation with other people (9.8%). A two-way ANCOVA on the metastrategic knowledge score revealed no significant effects of strategies, explanations, or strategies × explanations on the total number of strategies reported by the students, all $Fs \leq 1.68$, $ps \geq .198$. Next, we examined the effects of the misinformation game mechanics on the likelihood of mentioning each evaluation strategy using a series of binary logistic regression models controlling topic interest and knowledge. In the corroboration strategy, we identified significant main effects of simulating evaluation strategies, $\chi^2 = 4.80$, $p = .028$, and providing misinformation explanations, $\chi^2 = 4.96$, $p = .026$, along with a non-significant interaction, $\chi^2 = 1.66$, $p = .198$. Players who were exposed to the strategies were *more* likely to mention corroboration. In contrast, players who received explanations were *less* likely to mention corroboration. These effects are illustrated in Fig. 5.

In the sourcing strategy, the main effects of simulating evaluation strategies and providing misinformation explanations were not significant, $\chi^2s \leq 2.49$, $ps \geq .114$; however, a significant strategies × explanations interaction emerged, $\chi^2 = 9.91$, $p = .002$. Pairwise comparisons, with a sequential Bonferroni correction, indicated that players who were exposed to evaluation strategies alone ($p = .001$) and to misinformation explanations alone ($p = .008$) were significantly *more* likely to mention sourcing than players in the control condition. However, the difference between players in the strategy + explanation and control conditions was not significant ($p = .238$). The interaction is illustrated in Fig. 6. There were no significant effects on the likelihood of mentioning content evaluation, all $\chi^2s \leq 2.06$, $ps \geq .151$, and consultation strategies, all $\chi^2s \leq .34$, $ps \geq .558$.

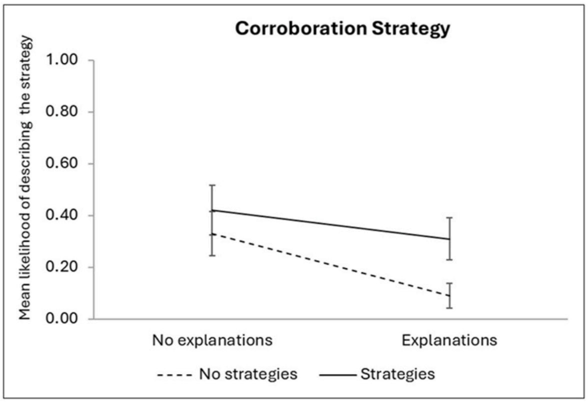


**Fig. 5.** Effects of Simulating Evaluation Strategies and Providing Misinformation Explanations on Metastrategic Knowledge About Corroboration
*Note*. Controlling for topic knowledge and interest. The error bars show the standard errors.

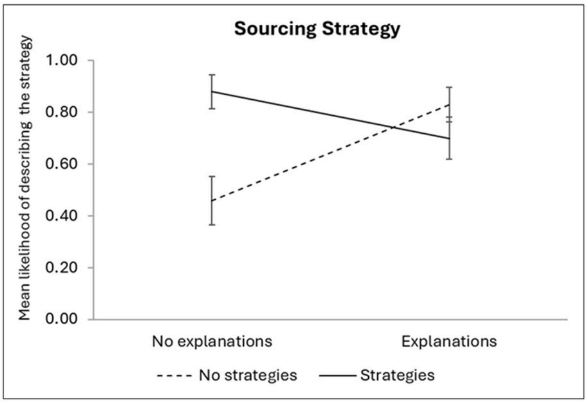


**Fig. 6.** Effects of Simulating Evaluation Strategies and Providing Misinformation Explanations on Metastrategic Knowledge About Sourcing
*Note*. Controlling for topic knowledge and interest. The error bars show the standard errors.

### 3.5. Mediating role of in-game performance

To start, we examined whether the game mechanics impacted players' in-game sharing accuracy score using a two-way ANCOVA, controlling for topic knowledge and interest, consistently with our previous analyses. There was a statistically significant effect of simulating evaluation strategies, $F(1,132) = 13.36$, $p < .001$, $\eta^2_p = .10$, indicating that players who played the version with evaluation strategies made more accurate sharing decisions in the game ($M = 8.49$, $SD = 2.49$ vs. $M = 7.03$, $SD = 1.88$). The effects of providing misinformation explanations and the strategies × explanations interaction were not significant, $F$s $\leq .32$, $p$s $\geq .570$.

In light of these findings, we tested a structural equation model with maximum-likelihood estimation that included simulating evaluation strategies as a predictor of the in-game sharing accuracy score. In turn, in-game sharing accuracy was hypothesized to predict post-game accuracy discernment and sharing discernment, as we assumed that learning to discern between messages in the game could lead to improved performance after the game. Additionally, in light of the relationship between accuracy discernment and sharing discernment (Pennycook et al., 2021), we also expected that accuracy discernment would predict sharing discernment. The model is illustrated in Fig. 7.

This model had excellent fit to the data ($\chi^{2}$=1.90, $df = 2$, $p = .387$, CFI = 1.00, RMSEA = .000, SRMR = .046). As expected, in-game sharing accuracy mediated the effect of simulating evaluation strategies on post-game accuracy discernment and sharing discernment. Notably, in-game sharing accuracy had a small but significant direct effect on post-game sharing discernment despite the strong effect of accuracy discernment on sharing discernment. This suggests that in-game performance might have impacted players' tendencies to share information more carefully, over and beyond their judgments of message accuracy.

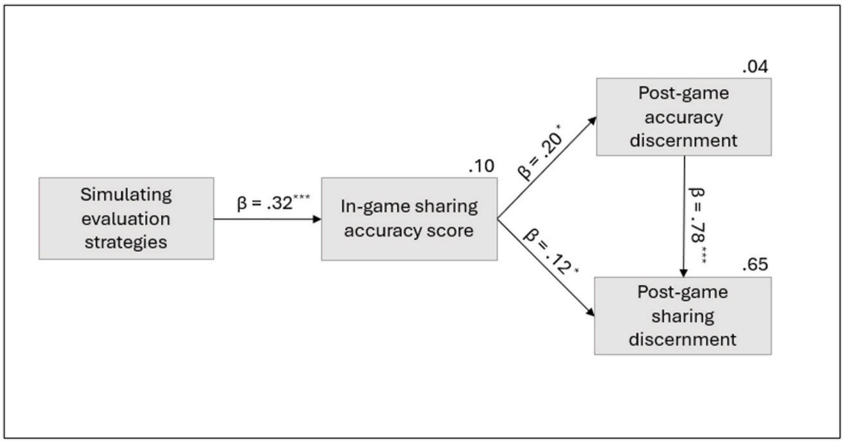


**Fig. 7.** Structural Equation Model of the Relations Between Simulating Evaluation Strategies, In-Game Performance, and Post-Game Performance
*Note*. Standardized coefficients.

## 4. Discussion

The goal of this study was to understand the effects of misinformation game mechanics on the development of adolescents' competencies for coping with misinformation. Although previous research has shown that digital misinformation games can improve players' competencies (Kiili et al., 2024), the specific game design elements that contribute to learning from misinformation games are not yet well understood. With this in mind, we investigated the effects of two emerging misinformation game mechanics: simulating evaluation strategies and providing players with explanations about different types of misinformation.

Our first research question focused on the contribution of simulating evaluation strategies to post-game performance. Based on prior studies that have demonstrated the benefits of evaluation strategy instruction (e.g., Hämäläinen et al., 2023; Pérez et al., 2018), we expected that simulating evaluation strategies in the game would positively affect players' accuracy judgments and sharing intentions following the game. As expected, participants who played the game version that simulated evaluation strategies had better accuracy discernment than participants who played a version of the game that did not simulate these strategies. This novel finding demonstrates that engaging with simulated strategies in a fictitious game world can result in transferable learning outcomes and support critical evaluation of authentic information outside the game. Further, simulating evaluation strategies also led to improved sharing discernment, suggesting that experiencing strategies in the game may have also supported more responsible sharing dispositions.

Our data indicated that students in the strategy conditions frequently used the evaluation strategies to check the messages in the game. This finding suggests that the game design encouraged students to interact with the strategies and provided opportunities to experience how they can be employed. These experiences could have deepened players' understanding of the value of critically examining sources and claims, which might have led them to scrutinize message sources and claims more carefully after the game. Another possible explanation is that because students were more actively involved in checking the messages in the game, they could have become more engaged in this activity and, consequently, more motivated to continue checking messages after the game. Furthermore, experiencing the benefits of using evaluation strategies in the game might have encouraged the players to employ these strategies after the game. Better accuracy discernment could have improved players' sharing discernment by helping them know which messages to share or not. Additionally, simulating evaluation strategies could also have affected sharing discernment more directly by modeling how messages should be checked before sharing and thereby encouraging dispositions of intellectual carefulness.

Nonetheless, simulating evaluation strategies only improved the accuracy judgments and sharing intentions of the *accurate* post-game messages and had no significant effects on the inaccurate messages, consistent with Barzilai et al. (2023, Study 1). One possible reason is that players generally distrusted the inaccurate post-game messages. This could have limited the ability to identify the effect of the game on judgments of misinformation. The post-game messages included authentic misinformation about COVID-19, and participants' prior knowledge about COVID-19 may have helped them identify these messages as false. Another possible explanation is that the game rewarded the sharing of accurate information, which could have encouraged players to endorse and share accurate messages.

The effects of simulating evaluation strategies on players' metastrategic knowledge partly confirmed our expectations. Simulating evaluation strategies resulted in higher awareness of the corroboration strategy compared to the group that was not exposed to the strategies, which is consistent with the results of both studies conducted by Barzilai et al. (2023). This indicates that simulating evaluation strategies in a game can contribute to players' metastrategic knowledge. It also suggests that players may have perceived corroboration as a salient and useful strategy in the game, perhaps because it enabled them to quickly determine if the information was well-supported.

The effects on sourcing were more complex: Simulating evaluation strategies led to higher awareness of sourcing among players in the strategy condition but not among those in the combined condition receiving both evaluation strategies and misinformation explanations. A possible explanation for this pattern is that learners in the combined condition may have been cognitively overloaded by the need to simultaneously attend to misinformation explanations and evaluation strategies (Sweller, 2011). This cognitive load might have prevented learners from fully internalizing the sourcing strategy. When secondary school students are required to process multiple facets of handling misinformation at the same time, their ability to focus on and benefit from each facet may be diminished, leading to less pronounced effects compared to when they can concentrate on a single approach to identifying misinformation.

Lastly, simulating evaluation strategies did not affect the overall number of strategies that students described. This could stem from the design of the evaluation strategies in the game and raises the possibility that a different design could potentially lead to greater enhancements to players' metastrategic knowledge. Future versions of the game could, for example, introduce strategies sequentially rather than presenting them all at once. This approach could help reduce the cognitive load associated with playing the game and ensure that learners focus more on each strategy. Additionally, future game versions might incorporate explicit strategy instruction that explains how to apply each strategy and when and why it should be used. This could potentially foster a better understanding of the evaluation strategies and the benefits of their use (Dignath & Veenman, 2021).

Our second research question addressed the effects of misinformation explanations on post-game performance. Inoculation against misleading communication techniques has been found to reduce belief in misleading messages (Traberg et al., 2022); therefore, we expected that providing explanations about the types of misinformation encountered in the game would help draw players' attention to the characteristics of misinformation and result in better post-game accuracy discernment and sharing discernment. However, providing misinformation explanations did not impact players' discernment at all. This could suggest that inoculation was not the primary learning mechanism in the game. However, another possible explanation is that encountering examples of misinformation in the game may have already had some inoculation effect, even without providing explicit labels and explanations. Alternatively, the misinformation explanations might not have been perceived to be sufficiently relevant to achieving the game objectives. For instance, understanding why conspiracy theories are popular is important for understanding this phenomenon; however, the explanations might not have sufficiently assisted players in identifying misinformation in the game and thus in achieving their goals. Consequently, players may not have perceived these explanations as relevant enough to process them deeply, which could have diminished their impact on learning. Moreover, the explanations were provided as brief, non-interactive texts that appeared after players had made their sharing decisions. This presentation format may have encouraged superficial engagement, as players could skim the text and quickly proceed to the next decision without fully processing the content. In contrast, the evaluation strategies were displayed just before learners made their sharing decisions, allowed for user interaction, and offered information that was directly relevant to making a successful sharing decision and achieving the game's objectives.

As Salen and Zimmerman (2005) have noted, the meaningfulness of gameplay depends on the broader effects of an action on the rest of the game. Hence, to enhance the effectiveness of misinformation explanations in future iterations of the game, it might be beneficial to integrate these explanations more deeply into the gameplay. For example, making the explanations interactive or directly tying them to the players' ability to achieve in-game goals could increase their perceived relevance and encourage deeper engagement. By doing so, the game could better leverage the instructional potential of these explanations and more effectively support players in developing critical discernment skills.

Nonetheless, players who received misinformation explanations were more likely to describe sourcing as a strategy for detecting misinformation than players who did not receive explanations. This suggests that the explanations might have heightened players' awareness of the importance of attending to message sources to avoid being taken in by misinformation. However, when only explanations were provided, and not strategies, the awareness of sourcing did not translate into improved capabilities to discriminate between accurate and inaccurate post-game messages. This suggests that understanding the value of sourcing might be insufficient (see also Paul et al., 2017). Students may also need opportunities to practice source evaluation so they can identify occasions in which this strategy is useful and grasp how to apply it in context.

Surprisingly, providing misinformation explanations reduced the likelihood of describing corroboration. Corroboration involves seeking out reliable sources of information and using them to verify claims. The misinformation explanations might have emphasized the dangers of online communication, which could have induced general skepticism regarding online information, including reliable information (Modirrousta-Galian & Higham, 2023; Roozenbeek et al., 2022). Such broad skepticism might have negatively impacted the perceived viability and value of corroboration. An alternative explanation could be that participants who received misinformation explanations may have perceived corroboration as less helpful because the explanations already provided them with direct cues for identifying misinformation. This perception could have led them to rely more on their own assessment of the contents and their sources instead of intending to search for additional information. As a result, corroboration might have seemed less necessary, reducing the likelihood of it being described as a useful strategy.

The third research question focused on the role of in-game performance as a potential mediator of the effect of misinformation game mechanics on post-game performance. We conjectured that simulating evaluation strategies and providing misinformation explanations would improve players' capabilities to evaluate and share information in the game and that players' in-game performance, in turn, would predict their accuracy discernment and sharing discernment after the game. These expectations were partly confirmed. Only simulating evaluation strategies positively affected players' in-game sharing accuracy. One possible explanation is that players utilized the strategies to evaluate messages in the game, resulting in improved in-game accuracy judgments and sharing decisions. In contrast, the misinformation explanations might not have sufficiently helped players determine the accuracy of the game messages. This challenge might be addressed by crafting explanations that better help players identify misinformation techniques in the game and providing players with more opportunities to practice identifying these techniques.

As expected, players' capabilities to evaluate and share information in the game, as reflected in their in-game sharing accuracy score, predicted their post-game accuracy and sharing discernment. To our knowledge, this is the first demonstration that in-game sharing decisions are associated with post-game judgments and sharing intentions. This suggests that the quality of players' decisions in the game can support better decisions after the game. The instructional implication of this finding is that providing game tools that can enhance players' evaluations and sharing in a game could be a promising way to promote better accuracy judgments and more responsible sharing intentions beyond the game.

### *4.1. Limitations and future directions*

Although this research offers important insights into the design of misinformation game mechanics that are conducive to learning, our study does not come without limitations. First, our findings reflect the effects of a single game that addressed a specific topic in a particular age group. Further, the game included only textual messages and did not represent all of the contextual features of social media messages, such as the identity of the person who shared the message and how many people interacted with the message. Therefore, before drawing general conclusions, additional studies are needed encompassing diverse topics, message types, sharing cues, and age groups. Second, our outcome measures addressed a topic that was related to the topic of the game (COVID-19) and, therefore, tested near transfer to a similar topic. It would be worthwhile to examine the effects of the game on further removed topics to examine how far these effects might transfer. Third, our study only evaluated the immediate effects of the game on learners' evaluation and sharing. It would be valuable to conduct follow-up assessments to determine if any long-term effects or changes in behavior occur due to engaging with the game (Bråten et al., 2019; Richter et al., 2022).

Fourth, because our discernment measures addressed COVID-19 misinformation, we preferred not to ask participants to search for the items and their sources online to minimize and control exposure to misinformation. Hence, the sharing and accuracy discernment measures reflect participants' tendencies to critically question sources and contents and do not indicate to what extent they can verify information by searching online for claims and sources. Future studies, addressing other topics, would need to examine how well the game supports verification through online searching, with and without additional searching practice. However, because the game is only a simulation, we expect it might need to be combined with real-world searching practice to effectively foster searching skills. Fifth and relatedly, this study's measures do not inform us to what extent learners would spontaneously apply the newly learned evaluation strategies in other contexts when they are not prompted to evaluate information. Finding ways to efficiently assess students' spontaneous evaluation performance is a methodological challenge facing the field.

Sixth, the process data revealed how successfully players shared information in the game but provided limited insight into the precursors of successful sharing. More process data, such as eye-tracking data, will be needed to understand better how students learn from observing evaluation strategies and reading misinformation explanations in the game. Finally, in this study, we limited ourselves to measuring cognitive learning gains at the individual level. It, therefore, remains unclear to what extent the misinformation game also leads to motivational and dispositional learning gains, such as increased self-efficacy in dealing with misinformation (Paciello et al., 2023) and intellectual humility (Vaupotič et al., 2022), or social gains, such as how students discuss and share unconfirmed information in class (Tay et al., 2023). While recent meta-analytic evidence suggests that digital games may foster affective-motivational outcomes more than traditional classroom instruction (Barz et al., 2024), further research is needed to examine whether this also holds for misinformation games in general or the present game, in particular.

Building on the insights of this study, we suggest several interrelated avenues for future research. First, it would be highly valuable to continue examining misinformation games using value-added designs (Clark et al., 2016; Mayer, 2016) that can shed light on the contribution of specific game design elements. By systematically unpacking the effects of various game mechanics and other content or design features, a better understanding of what makes misinformation games work and how to design effective games might gradually develop. Second, our results suggest that it could be productive to understand better the interplay between evaluation strategies and knowledge about various types of misinformation. While knowledge about misinformation may assist individuals in swiftly dismissing poorly supported or manipulative assertions, familiarity with evaluation strategies might prove indispensable for identifying false claims that do not have specific markers of misinformation as well as credible information. Yet, deciding when to examine messages for markers of misinformation and when to engage in more time-consuming corroboration or sourcing through lateral reading is a metacognitively challenging task that requires learners to monitor and regulate their evolving understanding (Barzilai & Zohar, 2014; Rouet & Britt, 2011). We argue that future interventions should aim to equip students with a diverse array of knowledge and strategies and provide them with metastrategic knowledge about when and why to use these cognitive resources so that they can react flexibly to the situational affordances of digital information environments.

Third, current misinformation games, including the present game, typically provide the same support to all learners, regardless of their prior knowledge or in-game performance. While this may be a reasonable starting point for game development, digital misinformation games offer a unique opportunity to move away from a one-size-fits-all instructional approach. Future research should, therefore, find ways to adapt the scaffolds learners receive in a misinformation game to their actual skill level and the difficulties they experience. Finally, to evaluate the learning gains from digital misinformation games, it is reasonable to initially evaluate their effects in isolation. However, if misinformation games are to have a lasting impact on student behavior, approaches are needed to integrate them into school lessons (Honey & Hilton, 2011; Richter et al., 2022). To this end, teachers need to be familiarized with misinformation games and how they might be integrated into longer instructional sequences to complement classroom interaction (Clark et al., 2018; Wouters et al., 2013).

### 4.2. Conclusions and implications

The proliferation of misinformation in digital media calls for pedagogical responses that are effective, easily scalable, and relevant to the learning habits of digitally savvy young people. Incorporating digital games into educational settings may be a practical and engaging approach to addressing misinformation. Our study contributes to advancing research on misinformation game design by identifying game mechanics that are conducive to learning. The findings highlight that simulating evaluation strategies in a game, particularly source evaluation and corroboration, can help young people extend their strategy knowledge, identify accurate information, and develop responsible sharing behaviors. Further research is needed to explore the integration of misinformation explanations into such games to enhance learners' abilities to identify misinformation. More broadly, our study demonstrates that digital games can potentially improve adolescents' abilities to evaluate information and discern accurate messages from misinformation. Such skills are urgently needed to equip young people with the critical competencies to make informed decisions and participate responsibly in a digital society.

## Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used Grammarly and ChatGPT to improve language and readability. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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None.

## CRediT authorship contribution statement

**Sarit Barzilai:** Writing – original draft, Visualization, Software, Project administration, Methodology, Formal analysis, Conceptualization. **Marc Stadtler:** Writing – original draft, Methodology, Formal analysis, Conceptualization.

## Declarations of competing interest

None.

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## Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.compedu.2024.105210.

## Data availability

The authors do not have permission to share data.

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