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Research Article

Can pre-service teachers learn about fake news by playing an augmented reality escape game?

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ABSTRACT

Fake news is increasingly becoming a major problem for global social coexistence, for example by undermining trust in democracies. There is a consensus that educational institutions need to respond and prepare students to recognize fake news. Teachers have a central role to play in preparing students and therefore need to learn about fake news during their studies. Previous research has shown that games are particularly effective for learning about fake news, but the group of pre-service teachers has not yet been investigated. The aim of this study is to address this gap by examining whether pre-service teachers can learn about fake news using the augmented reality escape game *Escape Fake*. To investigate this question, a pre-/post-test design was conducted with 45 pre-service teachers (four males, mean age=22.59 years, standard deviation=1.80). The results show that after playing *Escape Fake*, the pre-service teachers demonstrate significantly higher knowledge about fake news, are significantly more critical towards online information, and are significantly more confident in being able to recognize fake news in the future. However, playing the game did not promote the ability to discern real from false information. The paper discusses reasons for this finding and suggests ways to improve learning with the game. Implications and future research needs are discussed.

Keywords: fake news, fake news education, educational escape game, augmented reality, teacher education, teacher training

INTRODUCTION

Worldwide, the increasing spread of deliberately false and misleading information, known as fake news, via online media is becoming a problem for society. For example, fake news influence elections, reduce the acceptance of scientific findings such as human-made climate change, and, in the worst instances, lead to violent action (Allcott & Gentzkow, 2017; Comerford & Gerster, 2021; Traberg et al., 2022).

Although the deliberate dissemination of false information is not entirely new (Zarocostas, 2020), the increasing digital transformation has significantly contributed to making it more difficult to deal with fake news. For example, fake news is shared much more frequently on social media than real news (Vosoughi et al., 2018), and technological advances such as artificial intelligence (AI) tools make it even more difficult to distinguish between real and false news (e.g., *Deepfakes*; Chesney & Citron, 2019). Floridi and Chiriatti (2020) also expect that AI writing applications such as *ChatGPT* will make it easier to create and spread fake news by automatically tailoring texts to readers' beliefs.

In this context, Chinn et al. (2021) describe current media environments as "*complex and epistemically unfriendly*" (p. 51). These need to be countered in education through authentic learning experiences and the promotion of multiple learning objectives:

First, learners need knowledge and skills about how fake news is constructed, how it can be detected, and what tools are available to verify, for example, the authenticity of images or videos shared online (Apuke et al., 2022; Barzilai & Chinn, 2020).

In addition to these cognitive learning objectives, researchers point to the importance of attitudinal ones, such as fostering a critical attitude toward online information or confidence in one's ability to recognize fake news (Barzilai & Chinn, 2020; Roozenbeek & van der Linden, 2020; Vraga & Tully, 2021; Yang et al., 2021).

Teachers' Role in Educating About Fake News

Due the complexity of media environments and the difficulty to discern real from false news, both researchers and practitioners agree that the topic must be covered in class (Elmore & Coleman, 2019; Farmer, 2019). Teachers play a key role here as they are the ones who are responsible for preparing their students to navigate safely in these complex media environments by promoting the learning objectives described above (Caena & Redecker, 2019; Falloon, 2020). However, current studies argue that teachers are not prepared to teach about fake news. For example, Manfra and Holmes (2020) report that pre-service teachers knowledge and abilities in navigating digital media environments are lacking. Hence, Manfra and Holmes (2020) call for the integration of media literacy instruction in teacher education. Share et al. (2019) refer to the responsibility of teacher education institutions to train new teachers how to critically examine information sources. As a result, these teachers will also be able to teach students how to be more sensitive to information presented online and via social media.

To date, research on instructional approaches how to promote the above summarized learning objectives relevant in fake news education are scarce; for an exception see Cherner and Curry (2019). Most studies focus on the development of general media literacy skills or instructional approaches that are appropriate for students (e.g., Council of Europe, 2020). Therefore, it is necessary to implement and evaluate instructional methods in teacher education, which can promote teachers' knowledge, skills, and attitudes relevant to teaching about fake news in class.

One approach that has proven effective in learning about fake news for both youth and adults is playful learning (Roozenbeek & van der Linden, 2019a, 2019b).

Countering Fake News with Games

Several studies examined the effectiveness of games to promote the above-mentioned learning objectives relevant in fake news education:

Roozenbeek and van der Linden (2019a) developed a card game called *Fake News Game* in which players engage in role playing and fake news design. The aim of the game is to convince the other players of one's own opinion. In a field study, secondary school students who played the game were significantly better able to evaluate the reliability of fake news articles compared to a control group without an intervention.

Based on this first study, Roozenbeek and van der Linden (2019b) created the online game *Bad News* in which players design fake news to gain as many followers as possible for a fictive social media channel. Testing of the game was advertised by the BBC, among others, so data from almost 14,000 people was collected in a pre-/post-test design. In both tests, participants judged the reliability of Twitter postings. The results of the study show that after playing the game the participants were significantly better in rating the reliability of these postings with a corresponding large effect of η^2=0.27.

Basol et al. (2020) were able to replicate the effectiveness of the *Bad News* game regarding the promotion of discernment abilities. Further, Basol et al. (2020) demonstrated that the game also boosts participants' confidence to identify fake news in the future.

In another study on the *Bad News* game, Maertens et al. (2021) confirmed the positive effect of the game to improve participants' discernment ability. The effectiveness to foster confidence in fake news detection was also verified using another fake news game (*Harmony Square*; Roozenbeek & van der Linden, 2020).

Yang et al. (2021) developed the online game *Trustme!* in which players take on the role of a famous influencer who shares reliable information on social media. The learners' task is to review the postings and determine whether they are trustworthy or not. Per instant feedback after each decision, players learn about fake news design elements. In their study, Yang et al. (2021) demonstrated that the game can promote

students' information discernment skills. Furthermore, Yang et al. (2021) was interested in the effect of the game on participants' critical attitude toward online information. Regarding this learning objective, no significant advantage of the game compared to two active control conditions was found.

Paraschivoiu et al. (2021) developed an augmented reality (AR) escape game, *Escape Fake*, for media literacy education. The game uses AR technology, the computer-supported extension of reality (e.g., Klopfer & Squire, 2008), to simulate the escape the room gameplay. For example, by scanning images with a mobile device a virtual office appears in the real environment of the players. Through clicking, dragging, and dropping players pick up and combine objects to solve puzzles. The aim of the game is to debunk fake news spread on social media that discredited a bus driver as a human trafficker. A virtual teammate, the chatbot Hannah Lee May, supports the player(s) during the mission with hints and feedback. Additionally, after the players have successfully solved a riddle, multiple-choice quizzes appear and deliver information about fake news and how to conquer them. To win the game players must solve all puzzles within 25 minutes (Paraschivoiu et al., 2021). The effectiveness of the game on learning objectives relevant in media literacy education with a focus on fighting fake news was tested in Buchner (2022, 2023): the results show that playing *Escape Fake* promoted secondary school students knowledge about fake news, the ability to discern real from false news, a more critical attitude toward the trustworthiness of online information, and confidence in recognizing fake news in the future; the effect sizes were moderate to large with values from η^2=0.08 to η^2=0.65.

Summary & Research Gap

There is a consensus that educational institutions need to address the issue of fake news and prepare students to recognize such false information (Caena & Redecker, 2019). To ensure this in educational practice, teachers who are competent in dealing with the problem of fake news are needed. However, previous research on learning about fake news with games has neglected this population. As shown, studies that demonstrated the effectiveness of playful approaches in teaching about fake news focused on school students or adults in general. None of these studies aimed at promoting pre-service or in-service teachers' readiness to cope with fake news.

Therefore, in this study, we address this gap and test whether the game-based approach to conquer fake news promotes learning about fake news among pre-service teachers.

CURRENT STUDY WITH HYPOTHESES

The aim of this study is to extend and to contribute to the knowledge base on learning about fake news with games. Therefore, we address a target group neglected in previous research by investigating the effectiveness of a fake news game on pre-service teachers' learning.

We used the mentioned AR escape game *Escape Fake* (Paraschivoiu et al., 2021) for the following reasons:

The game is freely available making it possible for the pre-service teachers to use the game in the classroom after their graduation. Further, *Escape Fake* combines contemporary technology (AR) with an exciting gameplay (escape the room), which makes it an interesting educational resource for on-campus teaching in higher education (especially after the site closures due to COVID-19).

Furthermore, it is the only game of the listed ones whose effectiveness was tested on four learning objectives relevant in fake news education.

Escape Fake is designed and developed as an educational AR escape game incorporating instructional elements that are intended to educate players. For example, the mentioned multiple-choice quizzes as well as Hannah Lee May, who acts as a pedagogical agent, are such elements (Paraschivoiu et al., 2021). These instructional elements distinguish *Escape Fake* from other escape the room games that were not able to promote learning (e.g., Clauson et al., 2019; Cotner et al., 2018).

Based on these instructional characteristics of the game and previous results reported on the effectiveness of the game, we assume that *Escape Fake* can also promote pre-service teachers learning about fake news. In terms of learning outcomes, we follow the work of Buchner (2022, 2023) based on Apuke et al. (2022), Barzilai and Chinn (2020), Roozenbeek and van der Linden (2019b), and Yang et al. (2021) and investigate the impact of playing the game on four learning objectives:

Hypothesis 1 **Knowledge about fake news:** Playing the educational AR escape game *Escape Fake* increases pre-service teachers' knowledge about fake news.

Hypothesis 2 **Information discernment ability**: Playing the educational AR escape game *Escape Fake* increases pre-service teachers' ability to discern real from false news.

Hypothesis 3 **Critical attitude toward online information**: Playing the educational AR escape game *Escape Fake* increases pre-service teachers' critical attitude toward the trustworthiness of online information.

Hypothesis 4 **Confidence in recognizing fake news**: Playing the educational AR escape game *Escape Fake* increases pre-service teachers' confidence in recognizing fake news.

METHOD

Participants, Context, & Design

A total of 45 pre-service teachers, four males, with a mean age of 22.59 (standard deviation=1.80) years participated in the study. All participants study at the University of BLINDED to become foreign language teachers (primarily French, and/or Italian and Spanish) and attended the proseminar *Spielend lernen, lernend spielen? Spiele im Sprachunterricht* in the winter semester 2022/23 or the seminar *Le numérique en classe de FLE: une perspective de didactique des medias* in the summer semester 2023. The goal of the course was to get to know gamification as a concept, to reflect their own teaching and learning experience about digital media and games in language teaching, to develop new playful methods and open learning settings, to get to know different approaches to media theories and the use of digital media, especially games, in language teaching. Furthermore, students should deepen their theoretical knowledge regarding digital media and digital resources in the second language learning classroom. To test whether AR escape game *Escape Fake* can address the four relevant learning objectives, a field study with pre-/post-test design was conducted. The intervention took place during one class session. Data collection was done with an online questionnaire created with SoSci Survey (Leiner, 2019).

Instruments

Knowledge acquisition

To assess pre-service teachers' knowledge about fake news before and after playing the escape game, we applied the same test as in Buchner (2023) consisting of eight questions (see **Appendix A**). An example question is "what is a hybrid-fake?"–a combination of real and fake information, fake news about hybrid vehicles, a piece of information that is available both online and off-line, fake news that originated offline and only later found its way to the Internet.

The pre-service teachers answered each question by choosing one out of the four answers. In the pre-test, the students could also choose the option "I do not know". Each correct answer was rewarded with one point; hence, a maximum of eight points could be achieved in the knowledge acquisition test.

Information discernment ability

To measure pre-service teachers' ability to discern real from false information, we used eight simulated social media postings; four developed by German journalists (handysektor.de, 2017; see **Appendix B**) and four postings developed by the research team for the purpose of this study. The main reason for adding new postings was to adapt the test to the target group of adults. For example, postings were added that address content for adults, not for the target group of school students (as in the studies by Buchner, 2022, 2023).

Like in the work of Roozenbeek and van der Linden (2019a, 2019b), the pre-service teachers had to evaluate the reliability of each news posting on a 7-point Likert scale (1=not reliable at all, 7=very reliable).

Attitude toward online information

To determine whether the pre-service teachers are more critical after the intervention towards information spread online, we used a modified version of the *information verification scale* (IVS) developed by

Nee (2019). IVS consists of five items, for example, "I look at several sources to figure out whether I should believe it", answered on a Likert scale from 1=never to 7=always (see **Appendix C**; Cronbach's alpha pre-test=0.70, Cronbach's alpha post-test=0.80).

Confidence to recognize fake news

To assess whether the pre-service teachers are more confident in recognizing fake news after playing *Escape Fake*, we used a modified version of the *recognizing misinformation* scale developed by Khan and Idris (2019). The scale consists of three items, for example, "I can check the truth of stories and news reports, e.g., with the help of other sources", answered on a Likert scale from 1=do not agree to 7=fully agree (see **Appendix D**; Cronbach's alpha pre-test=0.76, Cronbach's alpha post-test=0.81).

Escape Fake

*Escape Fak*e is an AR escape game developed by an interdisciplinary team for the purpose of learning about fake news. This characterizes *Escape Fake* as an educational escape game, where instructional elements such as a supporting pedagogical agent and learning tasks are an integral part of the game design (Paraschivoiu et al., 2021). For example, in contrast to other escape games, time stops when players must work out the quizzes. This feature is of high importance because in other studies on escape games time pressure was found as a hindrance for learning (Veldkamp et al., 2021).

The game play of *Escape Fake* immerses players in a dystopian future in which fake news dominates social life. However, the player can change this future by helping a so-called reverse history hacker, named Hanna Lee May, in fixing crucial situations in history. To do so, player(s) solve riddles by collecting and combining virtual objects. For example, to smash a vase and reveal the key hidden inside, players click on a hammer and drag it onto the vase. The key can then be picked up and combined with other objects, when necessary. From a technological perspective, these interactions were realized with AR technology. AR allows the creation of motivating hybrid learning environments, which situate learners in relevant contexts, enables gesture-based and whole-body interactions with real and virtual objects, and evokes a sense of spatiality (Bacca et al., 2019; Krüger et al., 2019; Veldkamp et al., 2020a). These characteristics are important to mimic the idea of escaping the room. In *Escape Fake*, five marker images contain virtual information representing five different rooms. Players must explore and investigate each room to solve all riddles and to finally "escape the room"–which means in this case that the player(s) accomplished the mission within the time limit of 25 minutes successfully.

From a pedagogical perspective, the quizzes and the riddles teach information about fake news and how to detect them. For example, player(s) learn how fake news are designed and how to perform a reverse image search (e.g., Illinois University Library, 2020).

Technically, *Escape Fake* is designed as a marker-based AR game. This means that players need printed marker images that contain virtual information. Further, players need the free *Escape Fake* application installed on a mobile device with camera functionality (e.g., a smartphone or a tablet). When the application is opened, players can scan the images and afterwards the virtual information appears on the screen of the mobile device. Through clicking, dragging, and dropping players make use of virtual information and objects.

As mentioned earlier, the game proved to be effective in addressing multidimensional learning objectives. However, the results are limited to the population of school students.

Procedure

The study took place during one class session. The second author of this paper teaches both courses. First, the teacher welcomed the students and informed them about the intervention. Participation was voluntarily and possible after giving consent to participate. Then, an introduction on how to use the smartphone with *Escape Fake* AR application and the printed marker images to play the game was given. Afterwards, the marker images were distributed to each individual student. Due to space constraints, the authors used the rescaled markers developed by Buchner (2022). These markers enable them to play the game on a traditional desk.

Before the start of the game, each pre-service teacher answered the pre-test via the online questionnaire. Subsequently, the pre-service teachers used their smartphones to play *Escape Fake* game. After successfully "escaping the room", the participants filled the post-test. The intervention lasted a total of 45 minutes.

Table 1. Descriptive results for four variables assessed in this study

Variable	Pre-test		Post-test	
	Mean	Standard deviation	Mean	Standard deviation
Knowledge	4.38	1.76	7.02	1.10
Information discernment	5.48	0.47	5.46	0.44
Attitude	4.43	0.95	5.45	0.97
Confidence	4.04	1.21	5.30	1.26

Table 2. Results of paired samples t-test

Variable	Pre-test	Post-test	t(44)	p	d
	Mean	Mean			
Knowledge	4.38	7.02	8.862	<0.001	1.321
Information discernment	5.48	5.46	0.157	0.876	0.023
Attitude	4.43	5.45	4.421	<0.001	0.659
Confidence	4.04	5.30	4.863	<0.001	0.725

RESULTS

For data analysis purpose, we first aggregated the items to their respective scales using mean values. In the information discernment test, six postings represented fake news; hence, we recoded these tasks so that high values show correct reliability judgements.

For the knowledge test, correct answers were rewarded with one point and an overall sum was calculated. The participants could achieve a maximum of eight points.

Descriptive statistics for all variables measured in this study are given in **Table 1**.

To test the hypotheses one to four, a paired samples t-test was performed using the pre- and post-test results of the four learning measures (**Table 2**).

The results show that the pre-service teachers performed significantly better on the knowledge post-test than in the pre-test, the corresponding effect size is large; $t(44)=8.862$, $p<0.001$, $d=1.321$. Hence, we accept hypothesis one: Learning with *Escape Fake* promotes knowledge about fake news.

In the second hypothesis, we predicted that learning with *Escape Fake* can also facilitate pre-service teachers' ability to discern real and false information. As the results show, we must reject this assumption as no significant differences were found between pre- and post-test performance; $t(44)=0.157$, $p>0.050$, $d=0.023$.

Hypothesis three stated that pre-service teachers will be more critical towards online information after playing AR escape game. The results of the t-test confirm this assumption, the size of the effect is moderate; $t(44)=4.421$, $p<0.001$, $d=0.659$.

Also, the pre-service teachers are more confident in being able to detect false information after playing, the size of the effect is moderate; $t(44)=4.863$, $p<0.001$, $d=0.725$.

DISCUSSION

The aim of this study was to investigate whether playing a game can promote pre-service teachers' learning about fake news. In previous studies, this population was neglected; hence, the study contributes and extends the knowledge base on learning about fake news with games. Further, regarding the important role of teachers in preparing students to navigate complex media environments (Caena & Redecker, 2019; Falloon, 2020), the study contributes to teacher education and training by presenting the free-to-use AR game *Escape Fake* together with evidence on its effectiveness. As instructional approaches for preparing teachers to teach their students about fake news are scarce, demonstrating the effectiveness of the game in teacher education is a major contribution of this study.

First, we were interested in the learning objective of knowledge acquisition. As the result shows, the pre-service teachers demonstrated significantly higher knowledge about fake news in the post-test than in the pre-test; therefore, hypothesis one is confirmed. The effect is of large size and educationally relevant (e.g., Hattie, 2008). Promoting solid knowledge in a specific domain is an important aim in educational settings to

ensure future problem solving (Kirschner & Stoyanov, 2018; Tricot & Sweller, 2014). The importance of knowledge was also pointed out by researchers investigating how education can address the problem of fake news (Apuke et al., 2022; Barzilai & Chinn, 2020). Previous research reported that pre-service teachers lack the necessary knowledge to teach about fake news (e.g., Manfra & Holmes, 2020). This study shows that knowledge about fake news can be taught to pre-service teachers with the used escape game. Consequently, addressing the problem of fake news in the classroom becomes possible.

The results further prove that the game play and the instructional design elements, characterizing AR escape game *Escape Fake*, promote the necessary cognitive processing to acquire new knowledge. In other studies, examining learning with escape games no benefits of playing were found and teachers as well as students doubted the relevance of escape games in educational settings (e.g., Clauson et al., 2019; Hou & Li, 2014; Veldkamp et al., 2021). As mentioned in Paraschivoiu et al. (2021), especially the pedagogical agent named Hanna Lee May supports the learning process when playing the game as this supportive instructional element avoids cognitive overload and allows learners to focus on the content. The result of this study is in line with other studies in which positive results on knowledge acquisition were found when playing escape games primarily developed for educational purposes (Lopez-Pernas et al., 2019; von Kotzebue et al., 2022). In addition, the study provides evidence that the instructional design elements applied in *Escape Fake* can also promote knowledge about fake news among pre-service teachers, not just students (like in Buchner, 2023).

In the second hypothesis, we predicted that playing *Escape Fake* increases pre-service teachers' ability to discern real from false news. As the results show, we must reject this prediction: The pre-service teachers performed similarly in the pre-test and the post-test with no significant differences. The result contrasts previous studies using *Escape Fake* to promote information discernment ability (e.g., Buchner, 2023); however, in these studies students were the target group. A closer look at the result reveals that the pre-service teachers in this study were already proficient in judging the reliability of the used postings in the pre-test. Hence, it is possible that, although we used postings adapted to the target group of adults, the ability test was (still) too easy for the participants. However, beyond this possible measurement problem, instructional reasons might also account for the lack of an effect. For example, within *Escape Fake* players do not perform an information discernment task. Hence, this ability is not proactively promoted and, thus, if played by already skilled information discriminators no further improvement of this ability occurs. Consequently, if using the game, teacher educators and trainers should not use *Escape Fake* as an isolated instructional approach to promote learning about fake news but together with other methods like problem-based learning or lecturing. In general, research has shown that combining games with other learning activities or methods is more effective than just playing a game (e.g., Buchner et al., 2022; Fiorella & Mayer, 2012; Pilegard & Mayer, 2016). Specifically, for escape games researchers recommend debriefing activities after playing including reflecting and/or summarizing what was learned in the game (Buchner, 2023; Sanchez & Plumettaz-Sieber, 2019).

As future teachers not only need sufficient knowledge about fake news but also the ability to discern real from false news, the need to supplement AR escape game with other instructional approaches and strategies to promote information discernment abilities within the target group of pre-service teachers is a further major finding of this study.

In hypothesis three, we predicted that pre-service teachers' critical attitude toward online information will increase after playing *Escape Fake*. The results support this hypothesis, the respective effect size is moderate and educationally relevant. The finding is in line with previous research determining the effects of *Escape Fake* (Buchner, 2023) and the assumptions made by researchers regarding a possible effect of escape games on attitudinal learning outcomes (Borrego et al., 2017; Ouariachi & Wim, 2020; Veldkamp et al., 2020b).

Researchers explain the effect of escape games on attitudinal outcomes by the immersive experience of an authentic story that allows players to experience a challenging problem or situation from a first-person perspective (Monaghan & Nicholson, 2017; Veldkamp et al., 2020a). Within the story of *Escape Fake*, the players witness how easy it is to manipulate social media postings and experience firsthand the associated negative consequences for the life of a human being. As a result, the pre-service teachers were not only cognitively but also emotionally engaged contributing to a more critical attitude toward the trustworthiness of online information. It can be assumed that especially the combination of AR technology and the game-based learning approach is conducive to the experience of immersion and subsequently the promotion of attitudinal learning

objectives (Georgiou & Kyza, 2017). To prove this assumption further research is necessary in which researchers measure immersion as a (possible) factor affecting learning with AR escape game *Escape Fake*. For example, in another study determining the effect of an AR game on learning, higher immersion levels among participants were associated with higher motivation and learning (Georgiou & Kyza, 2018).

Lastly, we predicted that playing *Escape Fake* increases pre-service teachers' confidence to recognize fake news in the future. In line with previous research (e.g., Basol et al., 2020), learning about fake news with an educational game also significantly increases pre-service teachers' confidence to recognize fake news in the future. The effect size is moderate and educationally relevant. The increase can be explained by the games effect on improved knowledge about how to identify fake news and how to use tools to check online information. For example, in *Escape Fake* players first learn theoretically about reverse image research and then use the tool practically to solve one of the riddles. In sum, this contributes to a better understanding on how to deal with online information and, consequently, strengthens pre-service teachers' confidence in identifying fake news.

However, a careful interpretation of this result is necessary. In this study, higher confidence has not contributed to a better performance in the information discernment tasks. Thus, again, we recommend using *Escape Fake* as part of a well-planned and didactically sustained learning design to address the complexities of countering fake news and to prepare future teachers to address this issue in the classroom.

Limitations & Future Research

A limitation of the study is the sample size and the measure of learning outcomes only immediately after the intervention. Future studies should test *Escape Fake* game with a higher number of pre-service teachers; also, testing, with in-service teachers who participate in a professional development program or similar is recommended. Further, researchers should examine if playing *Escape Fake* contributes to long-term learning effects like reported for an online game in Maertens et al. (2021).

Moreover, although we investigated the impact of *Escape Fake* on four learning objectives relevant in fake news education, future studies should include other relevant learning outcomes like the intention to share fake news (Roozenbeek & van der Linden, 2020). Also, characteristics of the participants might be assessed in a future study, like one's own political view and how this view impacts learning about fake news (e.g., Lazer et al., 2018).

Another need is the development of a more difficult information discernment test to allow the measure of discernment ability with learners who are already skilled. Similarly, in the knowledge test questions with distinct difficulty levels could be added to increase the informative value of this instrument. Here, we recommend that the further development of the instruments should be done together with teachers and media literacy experts.

To adequately address the complexity of countering fake news (Barzilai & Chinn, 2020; Chinn et al., 2021) and to prepare (future) teachers to instruct students how to navigate safely in (complex) media environments (Caena & Redecker, 2019; Falloon, 2020), future research needs to investigate when and how to make learning with *Escape Fake* even more effective.

CONCLUSIONS

Fake news can be damaging to societies (Lewandowsky et al., 2020), so there is a need to explore effective teaching approaches to promote knowledge, skills, and attitudes in this area. Teachers have a crucial role to play, as they are the ones responsible for preparing students in schools to deal with today's complex media environments.

In this study, we demonstrated that AR escape game *Escape Fake* is an effective free-to-use educational resource to promote learning about fake news when used with pre-service teachers. However, we also found that experienced participants did not benefit from playing the game as an isolated learning opportunity in their ability to distinguish real from false information. Therefore, we recommend that teacher educators and higher education trainers use the game as part of a sustained learning design on how to navigate safely in

digital media environments such as social media. The effectiveness of such approaches is a matter for future research on how to prepare teachers to teach about fake news in the classroom.

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REFERENCES

Allcott, H., & Gentzkow, M. (2017). Social media and fake news in the 2016 election. *Journal of Economic Perspectives, 31*(2), 211-236. https://doi.org/10.1257/jep.31.2.211

Apuke, O. D., Omar, B., & Asude Tunca, E. (2022). Literacy concepts as an intervention strategy for improving fake news knowledge, detection skills, and curtailing the tendency to share fake news in Nigeria. *Child & Youth Services, 44*(1), 88-103. https://doi.org/10.1080/0145935X.2021.2024758

Bacca, J., Baldiris, S., Fabregat, R., & Kinshuk. (2019). Framework for designing motivational augmented reality applications in vocational education and training. *Australasian Journal of Educational Technology, 35*(3), 102-117. https://doi.org/10.14742/ajet.4182

Barzilai, S., & Chinn, C. A. (2020). A review of educational responses to the "post-truth" condition: Four lenses on "post-truth" problems. *Educational Psychologist, 55*(3), 107-119. https://doi.org/10.1080/00461520.2020.1786388

Basol, M., Roozenbeek, J., & Van der Linden, S. (2020). Good news about bad news: Gamified inoculation boosts confidence and cognitive immunity against fake news. *Journal of Cognition, 3*(1), 2. https://doi.org/10.5334/joc.91

Borrego, C., Fernández, C., Blanes, I., & Robles, S. (2017). Room escape at class: Escape games activities to facilitate the motivation and learning in computer science. *Journal of Technology and Science Education, 7*(2), 162. https://doi.org/10.3926/jotse.247

Buchner, J. (2022). *Lernen mit einem Augmented Reality Escape Game: Der Einfluss didaktischer Variationen auf den Lernerfolg und das Immersionserleben* [Learning with an augmented reality escape game: The influence of instructional variations on learning achievement and immersion experience] [Dissertation, University of Duisburg-Essen]. https://doi.org/10.17185/duepublico/75994

Buchner, J. (2023). *Effekte eines Augmented Reality Escape Games auf das Lernen über Fake News* [Effects of an augmented reality escape game on learning about fake news]. MedienPädagogik: Zeitschrift für Theorie und Praxis der Medienbildung, 51, 65–86. https://doi.org/10.21240/mpaed/51/2023.01.12.X

Buchner, J., Rüter, M., & Kerres, M. (2022). Learning with a digital escape room game: Before or after instruction? *Research and Practice in Technology Enhanced Learning, 17*(1), 10. https://doi.org/10.1186/s41039-022-00187-x

Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European digital competence framework for educators (DigCompEdu). *European Journal of Education, 54*(3), 356-369. https://doi.org/10.1111/ejed.12345

Chesney, B., & Citron, D. (2019). Deep fakes: A looming challenge for privacy, democracy, and national security. *California Law Review, 107*, 1753. https://doi.org/10.2139/ssrn.3213954

Chinn, C. A., Barzilai, S., & Duncan, R. G. (2021). Education for a "post-truth" world: New directions for research and practice. *Educational Researcher, 50*(1), 51-60. https://doi.org/10.3102/0013189X20940683

Clauson, A., Hahn, L., Frame, T., Hagan, A., Bynum, L. A., Thompson, M. E., & Kiningham, K. (2019). An innovative escape room activity to assess student readiness for advanced pharmacy practice experiences (APPEs). *Currents in Pharmacy Teaching and Learning, 11*(7), 723-728. https://doi.org/10.1016/j.cptl.2019.03.011

Comerford, M., & Gerster, L. (2021). The rise of antisemitism online during the pandemic: A study of French and German content. *European Union*. https://op.europa.eu/de/publication-detail/-/publication/d73c833f-c34c-11eb-a925-01aa75ed71a1/language-en

Cotner, S., Smith, K. M., Simpson, L., Burgess, D. S., & Cain, J. (2018). Incorporating an "Escape Room" game design in infectious diseases instruction. *Open Forum Infectious Diseases, 5*(suppl_1), S401. https://doi.org/10.1093/ofid/ofy210.1145

Falloon, G. (2020). From digital literacy to digital competence: The teacher digital competency (TDC) framework. *Educational Technology Research and Development, 68*(5), 2449-2472. https://doi.org/10.1007/s11423-020-09767-4

Fiorella, L., & Mayer, R. E. (2012). Paper-based aids for learning with a computer-based game. *Journal of Educational Psychology, 104*(4), 1074-1082. https://doi.org/10.1037/a0028088

Floridi, L., & Chiriatti, M. (2020). GPT-3: Its nature, scope, limits, and consequences. *Minds and Machines, 30*(4), 681-694. https://doi.org/10.1007/s11023-020-09548-1

handysektor.de. (2017). *Fakt oder fake: Das Handysektor fake news quiz* [*Fact or fake: The cell phone sector fake news quiz*]. https://www.handysektor.de/artikel/fakt-oder-fake-das-handysektor-fake-news-quiz/

Hattie, J. (2008). *Visible learning: A synthesis over 800 meta-analyses relating to achievement*. Routledge.

Hou, H.-T., & Li, M.-C. (2014). Evaluating multiple aspects of a digital educational problem-solving-based adventure game. *Computers in Human Behavior, 30*, 29-38. https://doi.org/10.1016/j.chb.2013.07.052

Illinois University Library. (2020). *Reverse image searching*. https://guides.library.illinois.edu/c.php?g=347668&p=2344601

Khan, M. L., & Idris, I. K. (2019). Recognize misinformation and verify before sharing: A reasoned action and information literacy perspective. *Behavior & Information Technology, 38*(12), 1194-1212. https://doi.org/10.1080/0144929X.2019.1578828

Kirschner, P. A., & Stoyanov, S. (2018). Educating youth for nonexistent/not yet existing professions. *Educational Policy, 34*(3), 477-517. https://doi.org/10.1177/0895904818802086

Klopfer, E., & Squire, K. (2008). Environmental detectives–The development of an augmented reality platform for environmental simulations. *Educational Technology Research and Development, 56*(2), 203-228. https://doi.org/10.1007/s11423-007-9037-6

Krüger, J. M., Buchholz, A., & Bodemer, D. (2019). Augmented reality in education: Three unique characteristics from a user's perspective. In *Proceedings of the 27th International Conference on Computers in Education*.

Lazer, D. M. J., Baum, M. A., Benkler, Y., Berinsky, A. J., Greenhill, K. M., Menczer, F., Metzger, M. J., Nyhan, B., Pennycook, G., Rothschild, D., Schudson, M., Sloman, S. A., Sunstein, C. R., Thorson, E. A., Watts, D. J., & Zittrain, J. L. (2018). The science of fake news. *Science, 359*(6380), 1094-1096. https://doi.org/10.1126/science.aao2998

Leiner, D. J. (2019). *SoSci survey (version 3.1.06)*. https://www.soscisurvey.de

Lewandowsky, S., Cook, J., Ecker, U., Albarracín, D., Amazeen, M. A., Kendeou, P., Lombardi, D., Newman, E. J., Pennycook, G., Porter, E., Rand, D. G., Rapp, D. N., Reifler, J., Roozenbeek, J., Schmid, P., Seifert, C. M., Sinatra, G. M., Swire-Thompson, B., van der Linden, S. … Zaragoza, M. S. (2020). *The debunking handbook 2020*. https://doi.org/10.17910/B7.1182

Lopez-Pernas, S., Gordillo, A., Barra, E., & Quemada, J. (2019). Analyzing learning effectiveness and students' perceptions of an educational escape room in a programming course in higher education. *IEEE Access, 7*, 184221-184234. https://doi.org/10.1109/ACCESS.2019.2960312

Maertens, R., Roozenbeek, J., Basol, M., & van der Linden, S. (2021). Long-term effectiveness of inoculation against misinformation: Three longitudinal experiments. *Journal of Experimental Psychology: Applied, 27*(1), 1-16. https://doi.org/10.1037/xap0000315

Monaghan, S. R., & Nicholson, S. (2017). Bringing escape room concepts to pathophysiology case studies. *HAPS Educator, 21*(2), 49-65. https://doi.org/10.21692/haps.2017.015

Nee, R. C. (2019). Youthquakes in a post-truth era: Exploring social media news use and information verification actions among global teens and young adults. *Journalism & Mass Communication Educator, 74*(2), 171-184. https://doi.org/10.1177/1077695818825215

Ouariachi, T., & Wim, E. J. L. (2020). Escape rooms as tools for climate change education: An exploration of initiatives. *Environmental Education Research, 26*(8), 1193-1206. https://doi.org/10.1080/13504622.2020.1753659

Paraschivoiu, I., Buchner, J., Praxmarer, R., & Layer-Wagner, T. (2021). Escape the fake: Development and evaluation of an augmented reality escape room game for fighting fake news. In *Proceedings of the 2021 Annual Symposium on Computer-Human Interaction in Play* (pp. 320-325). https://doi.org/10.1145/3450337.3483454

Pilegard, C., & Mayer, R. E. (2016). Improving academic learning from computer-based narrative games. *Contemporary Educational Psychology, 44-45*, 12-20. https://doi.org/10.1016/j.cedpsych.2015.12.002

Roozenbeek, J., & van der Linden, S. (2019a). Fake news game confers psychological resistance against online misinformation. *Palgrave Communications, 5*, 65. https://doi.org/10.1057/s41599-019-0279-9

Roozenbeek, J., & van der Linden, S. (2019b). The fake news game: Actively inoculating against the risk of misinformation. *Journal of Risk Research, 22*(5), 570-580. https://doi.org/10.1080/13669877.2018.1443491

Roozenbeek, J., & van der Linden, S. (2020). Breaking harmony square: A game that "inoculates" against political misinformation. *Harvard Kennedy School Misinformation Review*. https://doi.org/10.37016/mr-2020-47

Sanchez, E., & Plumettaz-Sieber, M. (2019). Teaching and learning with escape games from debriefing to institutionalization of knowledge. In M. Gentile, M. Allegra, & H. Söbke (Eds.), *Games and learning alliance* (pp. 242-253). Springer. https://doi.org/10.1007/978-3-030-11548-7_23

Traberg, C. S., Roozenbeek, J., & van der Linden, S. (2022). Psychological inoculation against misinformation: Current evidence and future directions. *The ANNALS of the American Academy of Political and Social Science, 700*(1), 136-151. https://doi.org/10.1177/00027162221087936

Tricot, A., & Sweller, J. (2014). Domain-specific knowledge and why teaching generic skills does not work. *Educational Psychology Review, 26*(2), 265-283. https://doi.org/10.1007/s10648-013-9243-1

Veldkamp, A., Daemen, J., Teekens, S., Koelewijn, S., Knippels, M. P. J., & Joolingen, W. R. (2020a). Escape boxes: Bringing escape room experience into the classroom. *British Journal of Educational Technology, 51*(4), 1220-1239. https://doi.org/10.1111/bjet.12935

Veldkamp, A., Knippels, M.-C. P. J., & van Joolingen, W. R. (2021b). Beyond the early adopters: Escape rooms in science education. *Frontiers in Education, 6*, 622860. https://doi.org/10.3389/feduc.2021.622860

Veldkamp, A., van de Grint, L., Knippels, M.-C. P. J., & van Joolingen, W. R. (2020). Escape education: A systematic review on escape rooms in education. *Educational Research Review, 31*, 100364. https://doi.org/10.1016/j.edurev.2020.100364

von Kotzebue, L., Zumbach, J., & Brandlmayr, A. (2022). Digital escape rooms as game-based learning environments: A study in sex education. *Multimodal Technologies and Interaction, 6*(2), 8. https://doi.org/10.3390/mti6020008

Vosoughi, S., Roy, D., & Aral, S. (2018). The spread of true and false news online. *Science, 359*(6380), 1146-1151. https://doi.org/10.1126/science.aap9559

Vraga, E. K., & Tully, M. (2021). News literacy, social media behaviors, and skepticism toward information on social media. *Information, Communication & Society, 24*(2), 150-166. https://doi.org/10.1080/1369118X.2019.1637445

Yang, S., Lee, J. W., Kim, H.-J., Kang, M., Chong, E., & Kim, E. (2021). Can an online educational game contribute to developing information literate citizens? *Computers & Education, 161*, 104057. https://doi.org/10.1016/j.compedu.2020.104057

Zarocostas, J. (2020). How to fight an infodemic. *The Lancet, 395*(10225), 676. https://doi.org/10.1016/S01406736(20)30461-X

APPENDIX A

Knowledge Acquisition Test

Statements in **bold** are correct and have each been awarded one point. A maximum of eight points could be achieved.

Table A1. Knowledge acquisition test

German items	English translation
Was ist ein hybrid-fake? • **Eine Kombination aus echten und falschen Informationen.** • Eine Fake News über Hybrid-Fahrzeuge. • Eine Information, die sowohl online als auch offline zur Verfügung steht. • Eine Fake-Nachricht, die offline entstanden ist und erst später den Weg ins Internet fand.	What is a hybrid fake? • **A combination of real and false information.** • A fake news about hybrid vehicles. • An information that is available both online and offline. • A fake news that originated offline and only later found its way to the Internet.
Was mach die reverse image search? • Findet für dich Bilder, auf denen du drauf bist. • Findet für dich Bilder, auf denen deine Freunde drauf sind. • **Findet für dich Webseiten, auf denen ein bestimmtes Bild zu finden ist.** • Findet für die Webseiten, auf die du Bilder kostenlos hochladen kannst.	What does reverse image search do? • Finds images for you that have you on them. • Finds pictures for you, where your friends are on. • **Finds for you web pages where a certain image can be found.** • Finds for you websites where you can upload images for free.
Warum werden fake news verbreitet? • Weil sie eigentlich die Wahrheit verbreiten. • **Weil sie von eigentlich relevanten Themen ablenken wollen.** • Weil sie die normale Berichterstattung ergänzen können. • Weil sonst die Wahrheit nicht ans Licht kommen würde.	Why do fake news spread? • Because they actually spread the truth. • **Because they want to distract from actually relevant topics.** • Because they can supplement normal reporting. • Because otherwise the truth would not come to light.
Was ist doxing? • Das Verwenden eines Bildes, um Geld zu machen. • Das Teilen eines Bildes in den sozialen Netzwerken. • **Das unerlaubte Teilen und Veröffentlichen von Daten.** • Der Verzicht auf alles Digitale für eine begrenzte Zeit.	What is doxing? • Using an image to make money. • Sharing an image on social media. • **The unauthorized sharing and publishing of data.** The abandonment of anything digital for a limited time.
Mit forensically kannst du… • Bilder manipulieren. • **Bilder auf Manipulationen untersuchen.** • Andere Computer infizieren und schädigen. • Andere Nutzer in sozialen Netzwerken ausspionieren.	With Forensically you can… • Manipulate images. • **Inspect images for tampering.** • Infect and damage other computers. • Spy on other users in social networks.
Ein impressum ist … • …für jede Seite im Internet verpflichtend. • **… ein Merkmal für eine vertrauenswürdige Homepage.** • … eine Datenbank für Bilder und Fotos im Internet. • … eine ausgedruckte Internet-Seite.	An imprint is … • … mandatory for every page on the Internet. • … a characteristic for a trustworthy homepage. • … a database for pictures and photos on the Internet. • … a printed web page.
Wie erkennst du ein fake profil in einem sozialen Netzwerk? • Die Profilseite ist ausführlich mit persönlichen Informationen gefüllt. • Die Profilseite zeigt eine Person mit vielen Kontakten. • **Die Profilseite beinhaltet nur wenige persönliche Informationen.** • Die Bilder der Profilseite sind qualitativ hochwertig.	How do you recognize a fake profile in a social network? • The profile page is filled extensively with personal information. • The profile page shows a person with many contacts. • **The profile page contains little personal information.** • The pictures on the profile page are of high quality.
Was ist scamming? • Ein Glücksspiel im Internet. • Ein Trend, der gerade im Internet häufig geteilt wird. • **Eine Form von Internet-Betrug.** • Werbung, die per Mail verschickt wird.	What is scamming? • A game of chance on the Internet. • A trend that is often shared on the internet right now. • **A form of Internet fraud.** • Advertising that is sent by mail.

APPENDIX B

Information Discernment Test

Each posting was rated by the participants on a scale from 1=not reliable at all to 7=very reliable. Simulated postings were designed and provided for reuse and publication by handysektor.de (2017).

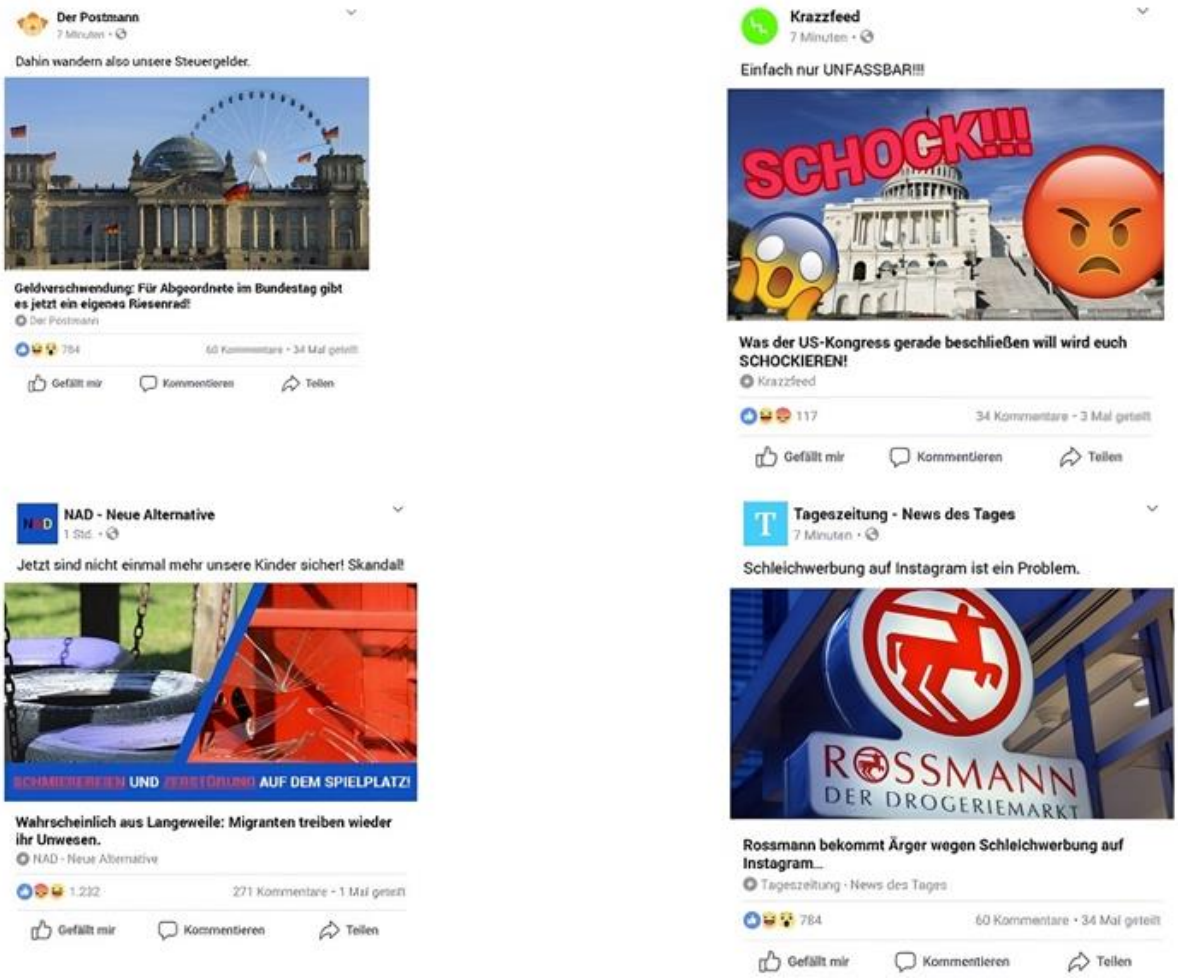

Figure B1. Fakt oder fake: Das Handysektor fake news quiz [Fact or fake: The cell phone sector fake news quiz] (handysektor.de. (2017). Fakt oder Fake: Das Handysektor Fake News Quiz. https://www.handysektor.de/artikel/fakt-oder-fake-das-handysektor-fake-news-quiz/, reprinted with permission)

Please note: For the other four postings used in the study titled **"Can pre-service teachers learn about fake news by playing an augmented reality escape game?"** the authors have no right for reuse and publication. Therefore, please write to the first author for more information about the postings. Thank you for your understanding.

APPENDIX C

Information Verification Scale

Participants answer the items on a scale from 1=never to 7=always.

Table C1. Information verification scale (based on Nee, 2019)

Modified German items	Modified original items
• Ich denke sorgfältig über die gefundene Nachricht nach. • Ich sehe mir die ursprüngliche Quelle der Geschichte an. • Ich sehe mir andere Quellen an, um herauszufinden, ob ich diese Information glauben kann. • Ich versuche so viele Informationen wie möglich über die Geschichte herauszufinden. • Ich versuche herauszufinden, was andere Menschen über diese Neuigkeit sagen.	• Think about the information carefully. • Look at the original source of the story. • Look at several sources to figure out whether you should believe it. • Get as much information as you can about the news. • Find out what other people are saying about the story.

APPENDIX D

Recognizing Misinformation Scale

Participants answer the items on a scale from 1=never to 7=always.

Table D1. Recognizing misinformation scale (based on Khan & Idris, 2019)

Modified German items	Modified original items
• Ich bin gut darin, falsche Informationen, Geschichten und Nachrichtenmeldungen, die im Internet und den sozialen Medien verbreitet werden, zu erkennen. • Ich kenne Tools und Programme, die mir beim Erkennen von Falschnachrichten helfen können. • Ich kann Geschichten und Nachrichtenmeldungen auf ihren Wahrheitsgehalt, z.B. mithilfe anderer Quellen, überprüfen.	• I am good at recognizing false information, stories, & news reports that are spread on the Internet & social media. • I know tools and programs that can help me recognize false news. • I can check stories and news reports for their truthfulness, e.g., with the help of other sources.