A Gamified Platform to Support Educational Activities About Fake News in Social Media

Sara Capecchi, Antonio Lieto, Federica Patti, Ruggero G. Pensa, Amon Rapp, Fabiana Vernero, and Sandra Zingaro

***Abstract*—The amount of news on the web often confuses the ideas of the reader, who struggles to disentangle information that is sometimes contradictory and difficult to decipher. In the face of such an articulated scenario, the role played by schools is absolutely central: the development of critical thinking in young people (and by extension in their families) is a necessary condition for facing the complexity of the reality with the right awareness and control. Providing young people with a thorough understanding of the fake news spreading phenomenon is a first step in combating it. To this end, in this article, we propose a serious game whose objective is to let young people experience the typical interaction scenario when faced to a feed of real and fake news in social media. Our proposal focuses on educational workshops, carried out in secondary schools and dedicated to the correct use of information on the web, with particular attention to logical fallacies and cognitive bias mechanisms that lead to the formulation of erroneous reasoning or prevent a comparison from progressing logically. Thanks to an intuitive interface that helps the teacher supervise the whole game session, the students are invited to assess the truthfulness of a small set of news at different levels and to share them with their friends. At the end of the game session, the teacher is provided with an interactive detailed report of the activities that enables the analysis of all participants' actions and behavior. The teacher can use such a report to conduct a classroom lecture in a more engaging and interactive way, by stimulating discussions among the students and raising their curiosity on the subject. Our educational platform has been tested accurately in a broad experimental study involving 217 middle school students. The results show the suitability of the platform in providing a valuable educational tool for supporting educational activities on fake news analysis.**

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Sara Capecchi is with the Department of Computer Science, University of Turin, 10124 Turin, Italy, and also with the Laboratorio Informatica e Scuola, Consorzio Interuniversitario Nazionale per l'Informatica, 00185 Rome, Italy (e-mail: sara.capecchi@unito.it).

Antonio Lieto is with the Department of Political, Social, and Communication Sciences, University of Salerno, 84084 Fisciano, Italy.

Federica Patti is with the Department of Computer Science, University of Turin, 10124 Turin, Italy, and also with the Italian Ministry of Public Education, 00153 Rome, Italy.

Ruggero G. Pensa, Amon Rapp, Fabiana Vernero, and Sandra Zingaro are with the Department of Computer Science, University of Turin, 10124 Turin, Italy.

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I. Introduction

THE intensive development of the World Wide Web since the mid-1990s has greatly improved and expanded the possibilities of communication among people. Online social media, such as X (previously Twitter) and Facebook, can facilitate the dissemination of real-time information between connected users from all over the world. Leveraging their main features, namely, ease of use, low cost, and speed, social media have become the main platform for online social interaction and information transmission [1]. However, due to the increasing popularity of online social media, the Internet has become an ideal breeding ground for the spread of fake news, such as misleading information, fake reviews, misleading advertisements, unfounded political statements, and so on [2]. Such content is called "fake news" and, being widely used to confuse and persuade online users, it has become a serious concern of industry, academia, and governments.

According to a 2020 Pew Research Center survey [3], 52% of U.S. adults prefer to inform themselves on digital platforms, be it a news website (26%), a search engine (12%), social media (11%), or a podcast (3%). In contrast, about a third say that they prefer television (35%), and only 7% and 5%, respectively, say that they learn their news through radio and print media.

Beyond these numbers, another important factor must be considered: the way news is accessed also changes with age. In fact, the survey shows that Americans aged 50 and over use both television and digital devices to inform themselves, while younger age groups turn almost exclusively to digital platforms to access news [3]. Of course, this is a worldwide phenomenon. For example, according to data from the Ital Communications report, "as many as 14.5 million Italians (30.1% of 14–80 year olds) use Facebook to access news, 12.6% of the population acquire information on YouTube (and the share is 18% among young people), and 3% on X (previously Twitter) (5% among younger people). Usually, social media are used in combination with other information sources. There are, however, 4.5 million Italians who only inform themselves on social networks and who are particularly exposed to fake news, which end up influencing their view of the world and conditioning their choices."[1]

[1][Online]. Available: https://www.corrierecomunicazioni.it/media/informazione-online-oltre-4-milioni-di-italiani-si-informano-solo-sui-social-network/

Thus, an important aspect emerges that cannot be ignored: the Internet and the use of digital devices also significantly influence adolescents as they are surrounded and immersed in the digital environment. They interact with digital devices both at home and at school and take advantage of the content available online for multiple purposes, such as building a social network, games, and entertainment but also accessing news and information. According to the Pew Research Center, 97% of adolescents claim to use the Internet daily and 46% admit to using it almost constantly [4].

With such widespread use of the Internet and social networks by young users, the importance of education and digital literacy at school level to cope with the new challenges posed by the Internet in relation to the spread of fake news is evident.

This is the aim of the Social4School project, developed at the Department of Computer Science of the University of Turin.[2] Given the complexity and sensitivity of the issues addressed, many competences are needed, which is why Social4School is developed in a collaboration between the Departments of Computer Science, Philosophy and Educational Sciences[3] and Psychology.[4] In addition, this project is the result of the cooperation of a multidisciplinary team, including the Interdepartmental Centres for Innovation and Educational Research and Teaching Update of the University of Turin,[5] schools in the Piedmont region, the Patto per la Scienza association,[6] and the Essere Umani association,[7] because it is only through dialogue and cooperation with the multiple actors involved that effective interventions for schools and families can be realized. The approach proposed by Social4School is a participative and interactive one, based on the use of the serious games. Our tool allows pupils and teachers to experiment in practice, but in a controlled environment (the classroom), the dynamics of the web and social networks, to convey to students the idea that every online action implies a personal responsibility and can potentially have an unexpected repercussion. The aim of the project is, therefore, to effectively address the issue of digital citizenship education, accustoming the youngest to a conscious use of the web, through realistic interactive simulations that are based on a balance between "fun" and "learning" and make the educational content an integral part of the game.

In this article, we present a serious game whose objective is to let young people experience the typical interaction scenario when faced to a feed of real and fake news shared by friends or other profiles in social media in a simulated and controlled environment. Our proposal focuses on educational workshops, carried out in secondary schools and dedicated to the correct use of information on the web, with particular attention to logical fallacies and cognitive bias, mechanisms that lead to the formulation of erroneous reasoning or prevent a comparison from progressing logically.

[2][Online]. Available: https://www.di.unito.it
[3][Online]. Available: https://www.dfe.unito.it/do/home.pl
[4][Online]. Available: https://www.dippsicologia.unito.it/do/home.pl
[5][Online]. Available: https://www.cirda.unito.it
[6][Online]. Available: https://www.pattoperlascienza.it
[7][Online]. Available: https://essereumani.org

Our approach has been validated in several school complexes in the Piedmont regional area in Northern Italy involving 217 students aged between 12 and 14. More specifically, with our empirical evaluation, we aimed at answering two research questions.

1) *RQ1:* Is the Social4School serious game on fake news a suitable tool for educational workshops involving secondary school students, in terms of usability and user experience?
2) *RQ2:* Does the presence of logical fallacies in fake and real news impact users' behavior during the game?

The rest of this article is organized as follows. In Section II, we discuss some closely related work. In Section III, we present the overall platform and the dynamics of the serious game, by also providing details on the implementation of the resulting Web application. The results of the broad experimental validation are reported in Section IV. Finally, Section VI concludes this article.

II. Related Work

The issue of fake news has a long history, but the emergence of social media has created favorable conditions that facilitate the spread of disinformation [5], [6], [7]. Fake news, particularly when it becomes disconnected from its original sources and contexts, can have detrimental effects on people, such as confusion, incorrect decision making, and distress [8]. In addition, fake news has blurred the distinction between what is seen as real and what is seen as fake, leading to a gradual erosion of trust in traditional news sources [8], [9].

In this landscape, one common approach to combatting fake news on social media involves detecting and moderating behavioral patterns and content. For example, X (previously Twitter) and Facebook take action against accounts displaying inauthentic behavior and provide features related to misinformation, such as the ability to report posts, tweets, or users for spreading false news, buttons offering details about the source of an article, and related articles (like fact-checking articles) prior to users sharing potentially fake news [10].

An alternate approach is to engage and support users in evaluating content and identifying falsehoods. This includes teaching media literacy, relying on professional fact-checking services and platforms (e.g., Hoaxy [11]), or employing user interfaces and browser extensions that convey credibility information to individuals [10].

Teaching critical evaluation of news may be particularly effective for children and young people. In fact, although young people's news consumption habits are greatly influenced by their parents' news socialization [12], children and young individuals appear to be particularly susceptible to fake news [13].

Research highlights that young people across various age groups, including middle school, high school, and college, exhibit very low levels of online news literacy [13], [14]. For this, numerous governments, schools, and organizations have implemented policies and programs to enhance children's digital literacy, with educators advocating for mandatory digital literacy education in schools [15]. In this sense, efforts have been made by countries such as the U.S., Canada, and the European Union to integrate digital literacy into school curricula [15],

[16]. However, researchers emphasize the need for innovative solutions tailored to the need of youth news consumption and their preferred modes of engagement [7], [13].

In this regard, leveraging games may offer a particularly effective approach to enhance news literacy among young people. Game-based and gamified approaches have been extensively used in education to address a variety of issues. According to recent meta-reviews, games and gamified approaches appear to be even more effective than many other forms of learning, since they can foster enthusiasm, provide feedback on performance, fulfill learners' needs for recognition, and promote goal setting [17]. Educational games may motivate learners through a variety of motivators, such as challenges, competition, control on the game world, curiosity, immersion, rules, and goals [18].

Several games have been developed to educate users about specific digital literacy issues [15]: MediaSmarts has designed a quiz to teach children about safe web browsing behaviors; Friend Inspector [15], Social4School [19], and Data Dealer[8] are serious games developed for social networks users to assess their understanding of how their personal content is visible to others and how to enhance privacy settings with the goal of promoting awareness regarding online privacy

To really motivate learners, previous research has highlighted that game-based approaches should consider relevant design aspects. Laine and Lindberg [18] mapped those design features that may influence learners' motivation when playing an educational game and that we took into account for the design of our game.

Among these, design aspects that appear relevant to the realm of fake news relate primarily to the fact that the challenges of the game should be of cognitive nature (in our approach, the challenge is to identify fake news from their title and description), requiring the player to synthesize previously covered learning materials and knowledge, and apply problem solving or critical thinking skills, so as to facilitate the learner's knowledge and skill acquisition processes [18].

Two important aspects refer to the fact that the game should: 1) provide feedback and access to performance data to both learners and educators and 2) offer moments of reflection, where the learner could understand her errors and reflect on her performance and learning activity [18]. To take into account the above issues, we provided a detailed feedback at the end of our game: the users discover the actual truthfulness level of the news they have posted or reposted during the session and check their answers to all the questions (see Fig. 2). All this information is also available to the teacher who can use it to conduct a subsequent interactive activity with their students, providing examples of different behaviors.

A final important design aspect is to relate the game to activities, with which players are already familiar, as this lowers the game's learning curve, allowing players to grasp the gameplay faster [18]. Concerning this point, to design the layout and content of the news shown to users, we worked with colleagues with extensive experience in media education topics aimed at teenage children.

[8][Online]. Available: https://datadealer.com/

In the realm of fake news, there are several online games and gamified approaches available, which may draw on some of the aforementioned design aspects.

Kiili et al. [20] conducted a systematic literature review on games designed for tackling misinformation on social media. FakeFinder, for example, is a gamified system that employs progress bars and badges, requiring users to evaluate a series of news items while providing instructions, feedback, and background information throughout the process [21]. Factitious aims to help players reflect more critically on fake news by encouraging an investigative mindset that should be applied both inside and outside of educational contexts: the main task of the player is to examine an article and make an informed decision about the type of news they are viewing [22]. In addition, Factitious has been designed to function as a playful survey system to gather information about users' perception of ambiguous online journalistic content [22]. BBC iReporter[9] is a browser-based adventure game where the player experiences their first day of work in the BBC press agency's social media team. The player's objective is to investigate a breaking news story about a nationwide social media outage and gather real-time updates for four news bulletins throughout the day. Specifically, the player must decide which sources, political claims, comments, and images should be deemed trustworthy as they contribute to the news production of the day [23]. NewsFeed Defenders[10] is a game where players learn and reflect on journalism standards, learning to identify false and misleading news while improving their digital literacy: the player becomes part of a fictional social media site and faces the challenge of protecting the site's integrity by identifying low-quality posts based on advertisements, deception, and false news.

Other games allow the player to take the role of a fact checker: In the Trustme! Game [24], players take on the persona of a well-known influencer tasked with assessing the trustworthiness of information. The gameplay involves the player evaluating online articles as either reliable or unreliable. Similarly, in MathE the Game, players assume the role of a fact inspector [25]. What sets this game apart from simple choice-based games is its support for players in recognizing fake news. It provides authentic verification tools, including search engines, reverse image search, image verification assistant, and debunking sites. In Go!Viral, players play as social media influencers and spread misinformation about COVID-19. They begin by exploring their fictional social media feed and gradually find themselves drawn into an echo chamber where misleading information and content designed to provoke outrage about COVID-19 are prevalent. These scenarios are strategically designed to evoke a sense of threat and motivation. Over three scenarios, players are motivated to accumulate "likes" and "credibility points" while gaining insights into three prevalent manipulation techniques [26]. *Misinformation Is Contagious* [27] is a game that models evaluation strategies and the social implications of sharing (in)accurate information. Similarly to our proposal, it is targeted at middle

[9][Online]. Available: https://www.bbc.co.uk/news/resources/idt-8760dd58-84f9-4c98-ade2-590562670096

[10][Online]. Available: https://www.icivics.org/games/newsfeed-defenders

school classes, but all the contents (news and posts) focus on the COVID19 pandemic.

With respect to the abovementioned approaches, we share many steps of content verification (analysis of text, URLs, images, date, and sources). The main differences are as follows.

1) In our case, users have feedback on the news and on the answers given to quizzes only at the end of the game, whereas the games mentioned earlier give immediate feedback with respect to the trustworthiness of the content; this is also the case of *Misinformation Is Contagious:* at the end of the game, users are shown personalized advice based on their behavior during the game and explanations of the information manipulation techniques encountered. The feedback we propose is more analytical but does not contain explanations that must instead be given by the teacher in the discussion/reflection phase. The teacher is supported in this phase by a guide[11] containing detailed explanations about the misinformation manipulation techniques used in the game.
2) We did not represent social network information (likes, comments, and number of shares); instead, we added a sharing phase in which the game participants can analyze the contents shared by their mates. We also asked them how the behavior of fellow players could influence their choice of content sharing.

With respect to the approaches above, our activity was designed with the intention of providing teachers from secondary school with a tool to deal in the classroom with the subject of analyzing content on the Internet as a means of combating disinformation. It is designed for educational use under the supervision of an educator (although the demo version allows the individual user to analyze content and verify the correctness of their analysis). For instance, the news-sharing phase and the reading of the news posted by fellow players aim to bring out how the behavior of friends can influence the propensity to share or not share content. End-of-game detailed reporting allows the teacher to identify these aspects and discuss them with the class.

All the abovementioned proposals including ours fall in the fake news detection category. Another popular gamification approach in fake news games allows the player to take on the role of a creator of misinformation, with the objective of generating and disseminating false information as effectively as they can. One example is the Bad News Game, where users assume the role of fake news spreaders, gaining insight into the mechanisms of deception by attempting to deceive others [28]. Similarly, Harmony Square recognizes and grants badges to players as they master various techniques for manipulating misinformation during the game. These badges serve to highlight the key learning elements of the game and offer players opportunities to showcase their proficiency [29].

The Escape Fake game stood out distinctly from other games due to its unique format as an augmented reality escape room game. Here, the ultimate goal from the perspective of the user experience is to immerse the player in the game world, by giving her the impression that she is playing in a real-life escape room. The theme of Escape Fake is the blurring lines between real and virtual, the misuse of media and technology, to the point of living in a post-truth world [30].

[11] [Online]. Available: http://di.unito.it/s4steachersguide

III. Gamified Educational Experience on Fake News Detection

In this section, we present our platform by providing the details of our serious game whose objective is to make young people play with the typical interaction scenario when they are faced to a feed of real and fake news shared by friends or other profiles in social media.

The educational/scholastic purpose of our game strongly conditioned the design of the phases and the development of the functionalities.

1) Our activity can be carried out without consulting other sources and without navigating outside the application. This requirement was strongly desired by the teachers in order to avoid the risks of students freely surfing the net in the classroom.
2) The approach we use is that of the sandbox, which allows content to be analyzed in a closed and protected context.
3) The actions and responses of each player are stored and contribute to the creation of an interactive report available to individual participants and the teacher/educator. The collective discussion and analysis at the end of the activity is an integral part of the educational intervention.
4) We addressed the explicit analysis of certain logical fallacies by presenting the same news item in many different versions.

The teacher leads the simulation and monitors the activity of each participant, by interacting with their control panel. Participants are invited to assess the truthfulness of a small set of news at different levels and to share them with their friends. Initially, they can provide a first evaluation at a glance, without entering in the details of the contents. They can then share some of the news on their profile page, according to their first judgment. After that, they are asked to analyze all components of the news (e.g., the title, the URL, the images, and so on) using a simulated browser and to decide whether to confirm or revise their previous assessment and sharing decision. At the end, they are engaged in a short interactive session where they can see which news their friends have shared, and decide whether to share them on their turn or not. All the actions are logged and can be used by the teacher to conduct personalized educational activities during or after the game sessions.

With our serious game, on the one hand, we invite young people to reflect on the communication style and language of news, especially as presented in social media feeds; on the other hand, by letting them discover the phenomenon of information spreading in the social graph, they can enhance their awareness about the risks and dangers of contributing to fake news propagation in social media.

In the following, we first provide a detailed description of the dynamics of the proposed game by also presenting the functionalities offered by the teacher's control interface. Then, we discuss the details and the choices on the design

methodology adopted by our team and how we implemented the web application that we used during our experimental activities.[12]

A. Dynamics of the Activity

Before getting into the details of the overall game dynamics, we introduce some preliminary notation that will be used in the rest of this article. Each game session is instantiated over a set $U = \{u_1, \ldots, u_N\}$ of N users (or participants) that are inserted into a randomly generated social graph. The link involving each pair of participants is always reciprocal; hence, given a pair of users $(u_i, u_j) \in U$, an edge between u_i and u_j means that users u_i and u_j are connected by a friendship link. The overall social graph is always connected (i.e., it consists of one single connected component), but every user is connected only to a subset of other users.

A set of n predefined posts, each one reporting a specific piece of news, randomly chosen from a set $P = \{p_1, \ldots, p_M\}$ of M news posts, is assigned to each participant. Every news post has an embedded truthfulness category denoting the truthfulness level of the news (fake or real) and the presence of a logical fallacy: $\{fake, real, fakeAP, realAP, fakeAV, realAV\}$ where AP stands for Ad Populum and AV stands for Ad Verecundiam.

Thus, two versions with fallacies were also produced for each news post, be it fake or real.

1) *Ad populum fallacy (appeal to the majority):* This mistake is made when a thesis is accepted as true only because the majority thinks it is. In this case, an attempt is made to elicit an emotional and popular acceptance of an argument without resorting to a logical justification for it. An example given to explain this type of fallacy is: "Everyone thinks nuclear energy is a calamity; therefore, nuclear power plants are a calamity." This type of argument is based on the following logical form: "If everyone believes that something is true, then it must be true" (or viceversa).
2) *Ad verecundiam fallacy (appeal to an inappropriate authority):* This is a fallacy in which a conclusion is accepted as true simply because an expert has said it is true, regardless of whether or not the expert's area of expertise is relevant to the conclusion. This fallacy is based on the feeling of respect and trust that people have for experts and celebrities, but we are in the presence of an *argumentum ad verecundiam* when citing as evidence the opinion of people who cannot legitimately be considered experts in that field. The *argumentum ad verecundiam* also occurs in other situations: when one brings in the generic opinion of "experts" in support of one's thesis without citing them, and even when one dismisses someone's objection to an expert on the grounds that the person making the objection is not himself or herself an expert.

In our experimental activities, we set $n = 2$ (that two posts assigned to each participant), and we randomly divided participants into three groups. For the first group, the system assigns one fake news post and one real news post to every participant. For the second group, the system presents one news post containing the ad populum fallacy; hence, participants receive a set of news consisting of either fakeAP and real, or fake and realAP news posts. Finally, participants in the third group get a news post with ad verecundiam fallacy; more specifically, the system assigns a set of two news containing either fakeAV and real, or fake and realAV news posts. The news have been created by our team by editing actual real or fake news. Each news post p_i has several standard components: a URL (url_i), a title (title_i), a body text (text_i), and an image (img_i), i.e., a photo or graphic art visually representing the news article. In the following, the notation term item_i stands for a generic component of the news article p_i. The set of posts p_j assigned to user $u_i \in U$ is $P^i = \{p^i_j\}_{j=1,\ldots,n}$.

The users can perform multiple actions on each post and items. More in detail, they can provide a trustworthiness score—from 1 (nontrustworthy) to 5 (trustworthy)—to each item_i of every posts p_i assigned to them. In addition, the participants are also asked to summarily evaluate the reliability of the source, date, and topic of each article.

The simulation works as described in Table I. The game starts after the teacher has set up the session with few parameters (e.g., total number of participants and name of the session) and has communicated a session code to the students. The session code is unique and allows the participants to join the game without having an account on the website. Once the session has been joined, the participant has to select an avatar and insert

TABLE I
DYNAMICS OF THE GAME EXPLAINED BY ITS DESCRIPTION OF THE DIFFERENT GAME PHASES

Step	Phase	Description
1.	–	the teacher configures the game session and start the it;
2.	–	the users configure their profile and join the game session, following the teacher's instructions;
3.	Phase 1.1	the users read three short news posts and assess the reliability of the source, date and topic (*article scanning*);
4.	Phase 1.2	the users choose which news posts to share on their own social profile (*at-a-glance decision*);
5.	Phase 1.3	the users express their opinion on the truthfulness of the news and explain why they have decided to post it or not to post it (*1st intermediate test*);
6.	Phase 2.1	the users assess every single item (url, title, text, image) of the news posts (*in-depth analysis*);
7.	Phase 2.2	the users chose which news posts to share on their own social profile (*reasoned decision*);
8.	Phase 2.3	if the users chose differently from Phase 1.2, they explain why (*2nd intermediate test*);
9.	Phase 3.1	the users can read and re-post news posted by their friend (*interactive phase*);
10.	Phase 3.2	the users express their opinion on the truthfulness of the news and explain why they have decided to re-post it or not to re-post it (*final test*);
11.	-	the users can see the results of their game session and discover the actual trustworthiness of the news.

[12]The game is publicly available at http://di.unito.it/social4schoolfakenews

TABLE II
QUESTIONS IN PHASE 1.1

Question item	Possible answers
The source of the article	• is familiar or known • is unknown • is missing
The date of the article	• is plausible • is not plausible • is missing
The topic of the article	• can be easily recognized • can be recognized but has some inconsistency or ambiguity • cannot be recognized

a nickname. Once all students have set up their profile, the teacher can start the game for all. In general, the game steps are asynchronous, thus letting all students work at their own pace, with only one synchronization point at the end of Phase 2.3 (*second intermediate test*). When all participants have completed such a game phase, the teacher can activate the following steps, which are asynchronous again. The detail of each game phase is as follows.

During the first phase, each participant u_i has to give a quick glance at every news post p_j^i assigned to them and answer three simple questions related to the trustworthiness of the source, date and topic of the article (Phase 1.1). The questions and possible answers are given in Table II. Once all three articles have been evaluated, the participant must decide whether to post them on their own profile or not (Phase 1.2). After that, they have to provide their opinion about the truthfulness of every news and explain why they have decided to post it or not (Phase 1.3). So, there are four possible combinations for each of the news: the user thinks the news is true and decides 1) to post it or 2) not to post it; the user thinks the news is false and decides 3) to post it or 4) not to post it. Depending on the case, a list of possible explanations with which to justify the choice is shown to participants: they can either choose one of the options or give a different answer using the free text option (see the schema in Table III). Notice that the answers given by users in the various phases of the game are recorded and displayed in the final report: this way, they can be used in the comparison and discussion phases at the end of the activity.

During the second phase, the news are shown again in a simulated browser and the students are asked to assess the trustworthiness of every single item item_j of each article p_j^i in a Likert scale from 1, for a completely untrustworthy item, to 5, for a fully trustworthy item (Phase 2.1). An example of assessment window is given in Fig. 1. Successively (Phase 2.2), participants can decide whether to post each news article or not, possibly changing the decisions taken during Phase 1.2. Finally, if for some article a different decision has been taken, students have to explain the reason of the change in a free text box (Phase 2.3).

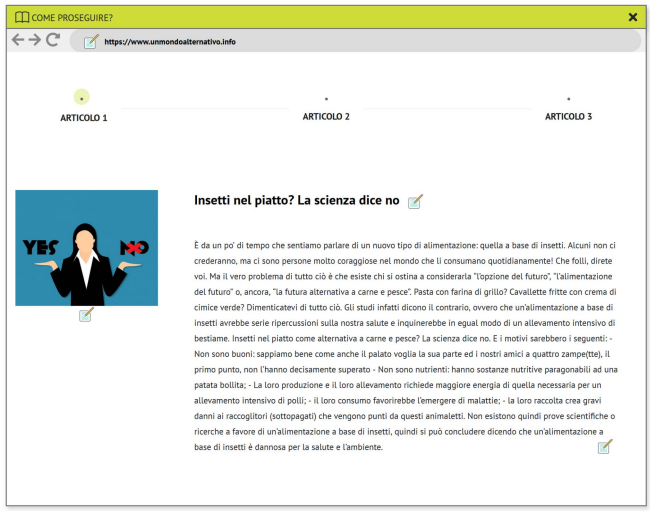

Fig. 1. Simulated browser windows used to assess every item of the news articles.

Fig. 2. Part of the final report shown to each participant.

When all students have completed Phase 2.3, they can read the news posted by their friends in the network and decide whether to repost them or not (Phase 3.1). At the end, similarly as in Phase 1.3, they have to express their guess about the truthfulness of the reposted news and explain why they have decided to repost it (Phase 3.2). The possible explanations follow the schema in Table IV.

At the end of the game, the users discover the actual truthfulness level of the news they have posted or reposted during the session and check their answers to all the questions (see Fig. 2). All this information is also available to the teacher who can use it to conduct a subsequent interactive activity with their students, providing examples of different behaviors.

B. Teacher's Control Panel

As already mentioned, all game steps and participants' activities are controlled by a single person that, in schools, can

TABLE III
POSSIBLE REASONS FOR POSTING OR NOT A NEWS ARTICLE AFTER A QUICK GLANCE

	Guessed truthfulness	
Posted?	**Real news**	**Fake news**
Yes	• Because I think it's interesting and I want others to know about it. • To know what others think, through comments and reactions. • For the simple fact that it is funny or curious news. • Because it's similar to the news I usually share. • Other (free text).	• Because, even if false, the news expresses ideas that I share and that I want others to know. • To provoke reactions in others and see what they think. • Because, even if it's not true, the news is funny or curious. • Because, even if it's not true, it's similar to the news I usually share. • Other (free text).
No	• Because I don't think it is interesting for me and for others. • Because I don't want my contacts to know what I think. • Because it's too different from the news I usually share. • Because, even if it's true, it's not funny or curious news. • Other (free text).	• Because I don't want to contribute to spreading false information among my contacts. • Because I'm afraid of what others might think if I share false information. • Because it's not funny or curious news. • Because it's too different from the news I usually share. • Other (free text).

TABLE IV
POSSIBLE REASONS FOR REPOSTING A NEWS ARTICLE

Guessed truthfulness	
Real news	**Fake news**
• Because a friend of mine also shared it. • Because I think it's interesting and I want others to know about it. • To know what others think, through comments and reactions. • For the simple fact that it is funny or curious news. • Because it's similar to the news I usually share. • Other (free text).	• Because a friend of mine also shared it. • Because, even if false, the news expresses ideas that I share and that I want others to know. • To provoke reactions in others and see what they think. • Because, even if it's not true, the news is funny or curious. • Because, even if it's not true, it's similar to the news I usually share. • Other (free text).

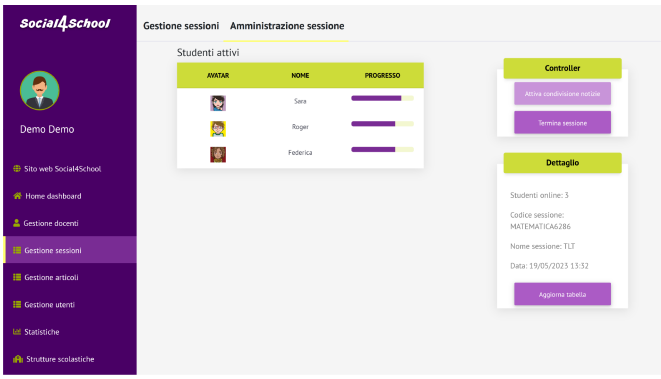

Fig. 3. Teacher panel, showing the dashboard for monitoring the participants' progresses in the game session.

be identified with the teacher. Differently from the students, the teachers must have their own username and password that allow them to log into their personal profile page on the Web application, where they have access to several functionalities, e.g., to start and manage new game sessions and browse the final reports of the participant's activities, through an intuitive game control panel. During the game session, a progress bar for each participant allows the teacher to identify issues and help students that are encountering difficulties or that have been disconnected for some reason (a screenshot of the teacher's panel is given Fig. 3). A special code can then be communicated to them in order to resume their game session to the last savepoint. The report returned at the end of the game session, instead, includes all answers given by the students to the different questions and their choices of posting and reposting news articles, together with the actual truthfulness level of the news and the indication of the type of logical fallacy used in the text (if any) and the part of the text where such reasoning error appears. All this information is designed to support any kind of educational activity aimed at promoting discussions around the game sessions just terminated, in a participatory and interactive way. In addition, users with teacher privileges can add novel news to the game scenarios through a visual interface allowing them to enter all news items, including some with logical fallacies.

C. Design Methodology, Implementation, and Security Issues

Our game has been included in an already existing educational platform, developed and maintained by our team, and named *Social4School*.[13] With the goal of extending it to multiple educational topics and games, we redesigned and re-developed the whole Web application, originally implemented in PHP and Javascript [19], and made it more modular. Hence, the new platform has been realized as a responsive web application using Node.js and Angular, hosted by HPC4AI,[14] a cloud-based high-performance computing system targeting AI workloads. Data are stored in a secured relational database managed with MariaDB. *Social4School* currently runs on a virtual quad-core

[13][Online]. Available: http://beta.social4school.net
[14][Online]. Available: https://hpc4ai.unito.it/

Intel Xeon E5-2697 v4 server equipped with 8-GB RAM, having Linux (Kernel release 6.4.4) as the operating system. Both the application and database servers are physically hosted at the Department of Computer Science of the University of Turin. The website and the game are in Italian, as the initial target users are Italian higher and lower secondary school students, and we want to make the overall game experience as natural as possible. A "demo" mode is also featured by the Web application: it can be used by anyone to test the game at any time.

The database is hosted in a different virtual server logically located in the same local subnetwork as the web server and cannot be reached directly. A full backup is executed weekly. No sensitive information is requested and stored, and all information entered by the participants is encrypted at the end of the game session. Only the teacher who conducted the activity can access the actual data using a dedicated decryption key, communicated at the end of the session, that only works for the specific game session. The whole design of the application follows the Privacy by Design and by Default principles of the General Data Protection Regulation (GDPR).

The web application has been realized by adopting a participatory design process that involved three computer scientists, two psychologists, three UI/UX experts, several bachelor's students, and a few secondary school teachers. The structure of the activity (phases and quiz), the elements to be analyzed (images, URLs, texts, etc.), and the contents of the activity (themes, texts, and fallacies) were devised and designed with a team of colleagues and students experienced in media education. We followed the Agile approach to design and implement a fully functional prototype, and we adopted the most recent usability and accessibility standards for the front end. It has been initially tested by a few students. Then, two test sessions were organized with a secondary school teacher and five lower secondary school classes. We exploited these preliminary test sessions to monitor the reactions of the participants and to take note of all major and minor bugs. We also collected the suggestions of the teachers involved and collaboratively edited a final report highlighting all necessary changes and improvements. Then, with the help of the UI/UX experts and a software developer, we released a new improved build of the Web application that we tested in further voluntary classes. Finally, after the correction of some minor bugs, in Spring 2023, we released the application effectively used in our experiments. The overall development stage lasted approximately four years, also due to the COVID-19 pandemic.

IV. Evaluation

As mentioned in Section I, we carried out a series of educational workshops in secondary schools with the aim of validating our approach.

In particular, we were interested in understanding whether the users (i.e., secondary school students) had a positive experience while playing our serious game in the context of an in-class educational workshop, since this is a prerequisite for its adoption (RQ1). To this aim, we measured the game usability, as well as users' experience and engagement with the game, through standard questionnaires administered after users had played with the Social4School platform.

In addition, we wanted to understand whether users behave differently with news containing logical fallacies (RQ2), due to their ability to boost people adherence to a certain argument, even if they base on illogical reasoning shortcuts and are not completely rational. To this aim, we analyzed behavioral data on news posting, comparing users' choices with fallacious and nonfallacious news.

Finally, we collected participants' answers to the questions presented in Section III: although they are mainly intended as a support for in-class educational activities and do not relate to the main goals of our evaluation, they are useful to better contextualize our results.

A. Methodology

1) Measures and Material: To assess *usability*, we adopted the System Usability Scale (SUS) questionnaire [31], a popular usability scale consisting of ten items.[15] Users are asked to assess their level of agreement with each item using a five-point Likert scale, ranging from "strongly disagree" to "strongly agree." For the purpose of computing usability scores, individual ratings are mapped to a 0–4 range. Since SUS represents an overall measure of the usability of a product, the scores for single items are not considered meaningful *per se*. Instead, to obtain the SUS score, ratings for even and odd items are treated differently: for odd items, which express positive usability evaluations, 1 is subtracted to the original rating, while, for even items (which are formulated so as to express negative perceptions of usability), the original rating is subtracted to 50. Then, all scores are summed up and finally multiplied by 2.5 to obtain a score in the [0–100] range. The average SUS score, based on 500 studies carried out by Jeff Sauro [32], is 68. Hence, a higher SUS score indicates that the system is considered satisfactory and easy to use, while a lower score highlights usability issues, suggesting that the solution is perceived as unpleasant or overly complex.

To assess *user experience*, we chose two different instruments, the Game User Experience Satisfaction Scale (GUESS) [33] and eGameFlow [34] questionnaires, each of which is composed by several subscales.

The GUESS [33] aims at measuring video game satisfaction. Although it was originally developed with commercial games in mind, designed for the sole purpose of entertainment, it was also applied to serious games in subsequent research (see, e.g., [35]). It consists of 55 items, grouped into nine subscales that refer to the following factors: Usability/Playability, Narratives, Play Engrossment, Enjoyment, Creative Freedom, Audio Aesthetics, Personal Gratification, Social Connectivity, and Visual Aesthetics. Users express their level of agreement with each item using a seven-point Likert scale, ranging from "strongly disagree" to "strongly agree."

To compute GUESS scores, the ratings of all the items referring to the same factor are averaged so as to obtain an average

[15]Example items for the SUS are: I think that "I would like to use this system frequently" or "I found the various functions in this system were well integrated."

score for each subscale.[16] Based on the standard interpretation of Likert scales, a score of 4 out of 7, corresponding to the scale midpoint, is considered to express a neutral evaluation, while higher scores indicate that users are satisfied with the system, and lower scores reveal negative opinions.

Following the authors' advice [33] and examples from previous research (see, e.g., [35]), subscales that do not seem to be relevant, for example, because they refer to features which are not included in the game under evaluation, can be omitted. In our evaluation, we selected the following subscales, which we deemed particularly relevant for our gaming platform: Enjoyment, Personal Gratification, and Visual Aesthetics. The Usability/Playability subscale was discarded because it investigates the same factor as the SUS instrument, i.e., usability, and would therefore provide no novel information. The Narratives, Play Engrossment, and Audio Aesthetics subscales were discarded because they focus on aspects, which, while being typical of video games, are absent in the Social4School platform: namely, the plot and characters, immersivity, and sound effects, respectively. Finally, the Creative Freedom and Social Connectivity subscales were excluded because our game engages individual users in well-structured activities that do not explicitly promote personal creativity (Creative Freedom) and do not require collaboration or competition with other players (Social Connectivity).

The eGameFlow [34] specifically targets e-learning games and measures the level of enjoyment provided to users. It consists of 42 items, grouped into eight subscales: Concentration, Goal Clarity, Feedback, Challenge, Control, Immersion, Social Interaction, and Knowledge Improvement. Similarly to the GUESS instrument, users express their level of agreement with each item using a seven-point Likert scale, ranging from "strongly disagree" to "strongly agree," and the eGameFlow score for each subscale is computed by averaging the ratings of all its items. Hence, scores close to the scale midpoint, 4 out of 7, convey a neutral judgment, while higher scores indicate that users enjoy the game and lower scores express dissatisfaction.

For our study, we focused on the following subscales: Concentration, Goal Clarity, and Knowledge Improvement. Similarly to the Play Engrossment and Social Connectivity subscales from the GUESS instrument, the Immersion and Social Interaction subscales from eGameFlow were discarded because they investigate aspects that are not explicitly supported in Social4School, i.e., immersivity and collaboration between players, respectively. The Challenge subscale was also discarded, since it refers to hierarchies of challenges that are typical of video games but do not specifically characterize our game. In addition, we selected one question from the Feedback and two questions from the Control subscales. The selected questions are: "I receive immediate feedback on my actions" (Feedback); and "I feel a sense of control over the game," "I know the next step in the game" (Control). The other questions in the Feedback and Control subscales were discarded because they either refer to generic usability issues, which are already covered through the SUS questionnaire, or mention specific game features that are absent in Social4School.

All three questionnaires were presented online through Google Forms after users had completed a game session with Social4School.

In addition, we used log data to study users' behavior: in particular, we tracked the news items that were presented to each user and which of them were posted.

2) Participants: The evaluation involved 217 middle school students, of which 52.07% were boys, 46.08% girls, and 1.84% identified as nonbinary, aged between 12 and 14 years (4.17% were 12 years old, 89.81% 13 years old, and 6.02% 14 years old), attending five different schools in Turin. Schools to participate in our research were recruited based on personal connections of the authors. We established a formal agreement with all those schools; we distributed the informed consent to the parents of all children possibly involved in our experiment and asked them for the signed privacy consent form. Only those children whose parents had signed the consent form were allowed to participate in our experiment.

Most participants are very familiar with the Internet and social networking applications. In fact, the majority of participants reported spending approximately 2 h on the Internet (31.80%), followed by those who admitted to spending more than 4 h (29.49%), and those who spend about 3 h (26.27%). Only 8.29% of the participants claimed to spend only 1 h online, and even fewer (4.15%) stated that they spend less than 1 h on the Internet. In addition, 92.17% of the participants have their own profile on a social network or gaming website, and 71.89% of them even have more than one. As far as the phenomenon of fake news is concerned, almost all participants claimed to be already aware of it and of the fact that fake news is deliberately created to deceive people.

B. Analysis of Users' Gaming Behavior

Sixty-one users (28%) posted fake news in phase 1.2 (see Table I), before having a chance to carry out a detailed analysis. Interestingly, this number decreased in phases 2.2 (43 users, 20%) and 3.1 (40 users, 18%), where users made more reasoned decisions based on their assessment of news features and on information about the behavior of their friends.

If we take into account user beliefs about the truthfulness of news items, we can observe that, in phase 1.2, users posted almost as many news they surmised to be fake (209 items, 49,5%) as they surmised to be true (213 items, 50,5%). When asked about their reasons for posting news items, students who posted news they believed to be true mainly referred to their desire to share interesting information with others (112 answers, 61%) and to know what others thought about it (39 answers, 21%). On the contrary, users who shared news they believed to be false mainly stated they either found it to be funny/curious (16 answers, 31%) or wanted to provoke reactions in others and see what they thought (14 answers, 27%). Considering the users' reasons for *not* posting news, their answers are almost evenly distributed among the three options that refer to personal tastes

[16]Only one item in the Enjoyment subscale, "I feel bored while playing the game," conveys a negative opinion and needs to be reversed before the average score for such subscale is computed.

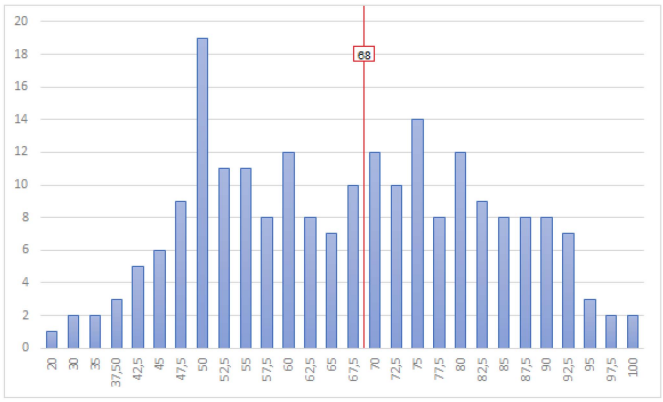

Fig. 4. Frequency distribution of SUS scores for the Social4School platform.

(13 answers each, 30%),[17] when discarded news are thought to be true. On the contrary, most users stated that they did not "want to contribute to spreading false information" (128 answers, 75%) when they explained why they chose not to post news they believed to be fake.

Coherently with the aforementioned finding about the decreasing number of fake news posted as the game proceeded, in phase 3.1, users shared many more news they believed to be true (209 items, 84%) than they believed to be fake (39 items, 16%), thus implicitly confirming the positive effect of the in-game activities. Interestingly enough, however, only 23 (8%) of the users who shared news they believed to be true and 4 (10%) of the users who shared news they believed to be false admitted to have been influenced by the behavior of their friends ("Because a friend of mine also shared it.").

C. RQ1: Results on Usability and User Experience

In the following, we present detailed results on the usability and user experience of the Social4School platform, as well as on the impact of logical fallacies on users' posting behavior.

1) Usability: Considering the ratings provided by all the students participating in our research, we obtained an average score of 66.7, which is slightly below the conventional threshold of 68 [32]. Specifically, 106 (out of 217) students provided an overall usability rating above 68, while 111/217 participants evaluated the gaming platform negatively (below 68) (see Fig. 4).

To gain a more detailed understanding of any specific issues with the platform, we examined the scores for individual items. The items that collected the most negative opinions are the following: 79 students stated that they would not use the game frequently, 39 students believed that they would need to learn many things before being able to use the game, 36 students stated that they would need support from someone who is already proficient in using the platform, 33 students found inconsistencies among the various game functionalities, and, finally, 30 participants admitted that they lacked confidence in using the platform. Hence, it seems that the most negative point concerns students' lack of interest in using the system frequently, which might be a relatively scarcely critical aspect, since the Social4School game is meant to be played only during a small number of well-focused in-class activities. A minor issue is related to the difficulties experienced by a few students in using the platform functionalities, which they perceived as unnecessarily complex and difficult to learn.

[17]The three options referring to personal tastes are: "Because I don't think it is interesting for me and for others," "Because it's too different from the news I usually share," and "Because, even if it's true, it's not funny or curious news."

TABLE V
AVERAGE SCORES FOR THE GUESS SUBSCALES, WITH FREQUENCY DISTRIBUTION OF USER ANSWERS TO ALL THE ITEMS

ENJOYMENT: 4.22 (st.dev: 0.13)									
Questions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**avg.**	**st. dev**
I think the game is fun	22	19	28	47	35	46	20	4.25	1.78
I enjoy playing the game	18	21	28	53	38	29	30	4.29	1.77
I feel bored while playing the game (R)	16	22	34	45	29	40	31	4.35	1.81
I am likely to recommend this game to others	28	17	41	45	31	33	22	4.02	1.82
If given the chance, I want to play this game again	25	25	28	36	35	25	35	4.18	1.95
PERSONAL GRATIFICATION: 4.50 (st. dev: 0.25)									
Questions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**avg.**	**st. dev**
I am in suspense about whether I will succeed in the game	23	20	31	49	37	30	27	4.18	1.81
I feel successful when I overcome the obstacles in the game	18	12	32	45	42	32	30	4.41	1.75
I want to do as well as possible during the game	5	16	19	50	34	46	47	4.93	1.64
I am very focused on my own performance while playing the game	17	15	25	47	51	41	21	4.41	1.67
I feel the game constantly motivates me to proceed further to the next stage or level	13	16	31	46	36	46	29	4.52	1.71
I find my skills gradually improve through the course of overcoming the challenges in the game	12	11	31	53	41	43	26	4.53	1.62
VISUAL AESTHETICS: 4.63 (st. dev.: 0.21)									
Questions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**avg.**	**st. dev**
I enjoy the game's graphics	12	17	30	51	38	42	27	4.47	1.67
I think the graphics of the game fit the mood or style of the game	9	10	27	41	36	57	37	4.86	1.64
I think the game is visually appealing	9	11	34	55	40	44	24	4.54	1.56

2) User Experience—GUESS: Table V presents the average scores for the GUESS subscales, together with the frequency distributions of user answers to all the questions.

For all three subscales (Enjoyment, Personal Gratification, and Visual Aesthetics), the average score is slightly-to-moderately higher than 4, the scale midpoint corresponding to a neutral assessment, thus indicating that students had a positive experience on the whole.

The overall score for the Enjoyment subscale, 4.22, is the lowest. However, by examining the positive and negative ratings of individual items more closely, we can see that the positive ratings (around 45%) are consistently more numerous than the negative ones (around 30–35%). The only exception is the fourth item, where 86 users (39.6%) stated that they would be likely

to recommend this game to others (answers: 5–7), and as many expressed the opposite opinion (answers: 1–3).

The overall score for the personal gratification subscale is 4.50. Once again, the positive ratings for individual items outweigh the negative ones, with a gap varying between 20 and 40 percentage points (pp) in most cases. The only exception is the first item, where the difference amounts to only 9.2 pp: in fact, 94 users (43.31%) were interested in finding out if they would win the game (answers: 5–7), while almost as many (74 users, 34.11%) were of the opposite mind (answers: 1–3). Differently, the item with the larger difference (40.1 pp) is the third one, since 127 users (58.53%) agreed with wanting to do their best during the game (answers: 5–7), and only 40 (18.43%) did not (answers: 1–3).

Finally, the overall score for the visual aesthetics subscale is the highest, namely, 4.63. Also in this case, positive ratings are more numerous than negative ones for all three items, with a percentage difference being consistently above 20 pp. The item that obtained the highest consensus (4.86) is the second one, which investigates the appropriateness of the graphics with reference to the style and mood of the game.

3) User Experience—eGameFlow: Table VI presents the average scores for the eGameFlow subscales, together with the frequency distributions of user answers to all the questions.

For all three subscales (Concentration, Goal Clarity, and Knowledge Improvement), as well as for the individual questions on Feedback and Control, the average score is moderately higher than 4, which indicates a positive overall assessment.

The overall score for the Concentration subscale is 4.67, which is slightly higher than the scores obtained by the other two subscales. By examining the positive and negative ratings of individual items more closely, we can observe that, once again, the positive ratings outweigh the negative ones, with a difference ranging from 24% to 43% approximately. The item where such difference is the largest (43.26%) is the last one, where 127 users (61.05%) agreed that the level of engagement required by the game is appropriate (answers: 5–7), and only 37 participants (17.79%) were negative to this respect (answers: 1–3).

The overall score for the Goal Clarity subscale is 4.64. Also, in this case, all items obtained positive ratings for the most part. The item with the highest level of agreement is the second one: 125 students (58.69%) stated that the overall goals of the game were presented clearly (answers: 5–7).

The overall score for the Knowledge Improvement subscale is 4.64. Positive ratings outnumber the negative ones for all items; in particular, the item with the largest gap (41.93%) is the second one, where most users (125, 57.6%) stated that they grasped the basic ideas of the taught knowledge (answers: 5–7).

Finally, we discuss the results obtained by the three individual questions extracted from their respective subscales. The item from the Feedback subscale obtained an average score of 4.56 out of 7. In particular, 114 students (52.53%) affirmed that the game provides immediate feedback for their actions (answers: 5–7), while 50 participants (23.04%) expressed full or partial disagreement with this statement (answers: 1–3). The first item from the Control subscale obtained a mean score of 4.68 out of 7. In this case, 119 users (54.84%) believed that it is always clear what the next phase of the game is (answers: 5–7), while 40 of them (18.43%) were of the opposite mind (answers: 1–3). The average score for the second item of the Control subscale is 4.48 out of 7. Specifically, 111 users (51.15%) stated that they feel in control of the game, while 49 users (22.58%) expressed a negative opinion. Considering the scale range ([1–7]), all three scores for the individual questions are higher than average and, therefore, reflect a positive attitude toward the game.

TABLE VI
AVERAGE SCORES FOR THE EGAMEFLOW SUBSCALES, WITH FREQUENCY DISTRIBUTION OF USER ANSWERS TO ALL THE ITEMS

CONCENTRATION: 4.67 (st. dev: 1.20)									
Questions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**avg.**	**st. dev**
Most of the gaming activities are related to the learning task	4	10	20	55	44	48	30	4.84	1.46
No distraction from the task is highlighted	4	10	35	56	40	43	20	4.57	1.45
Generally speaking, I can remain concentrated in the game	8	15	26	42	41	56	26	4.71	1.60
I am not distracted from tasks that the player should concentrate on	10	14	26	60	42	36	23	4.47	1.57
I am not burdened with tasks that seem unrelated	12	10	29	56	49	30	25	4.47	1.58
Workload in the game is adequate	10	6	21	44	41	42	44	4.93	1.64
GOAL CLARITY: 4.64 (st. dev: 1.18)									
Questions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**avg.**	**st. dev**
Overall game goals were presented in the beginning of the game	11	8	23	67	33	43	25	4.58	1.56
Overall game goals were presented clearly	13	7	18	50	41	39	45	4.86	1.69
Intermediate goals were presented in the beginning of each scene	10	13	28	65	37	31	25	4.43	1.57
Intermediate goals were presented clearly	8	10	24	60	40	45	30	4.70	1.55
KNOWLEDGE IMPROVEMENT: 4.64 (st. dev: 0.25)									
Questions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**avg.**	**st. dev**
The game increases my knowledge	15	13	25	44	42	39	39	4.65	1.76
I catch the basic ideas of the knowledge taught	5	7	22	58	51	45	29	4.82	1.43
I try to apply the knowledge in the game	9	13	21	46	40	54	34	4.81	1.63
The game motivates the player to integrate the knowledge taught	10	12	19	55	51	36	34	4.70	1.59
I want to know more about the knowledge taught	18	13	39	50	45	38	14	4.20	1.62
Individual questions									
Questions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**avg.**	**st. dev**
I receive immediate feedback on my actions	11	12	27	53	52	33	29	4.56	1.59
I know next step in the game	10	13	17	58	49	38	32	4.68	1.59
I feel a sense of control over the game	15	15	19	57	51	33	27	4.48	1.65

D. RQ2: Fallacies and Posting Behavior

Here, we analyze the posting behavior of the users in our experiments in relation to the presence of logical fallacies in the news articles they have to consider during the game.

Sixty-six users (30%) posted news containing fallacies in phase 1.2 (see Table I), while 164 users (75%) posted "neutral"

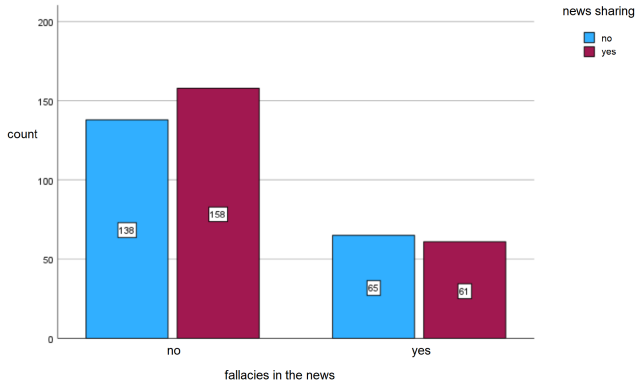

Fig. 5. Relationship between the presence of fallacies and news posting.

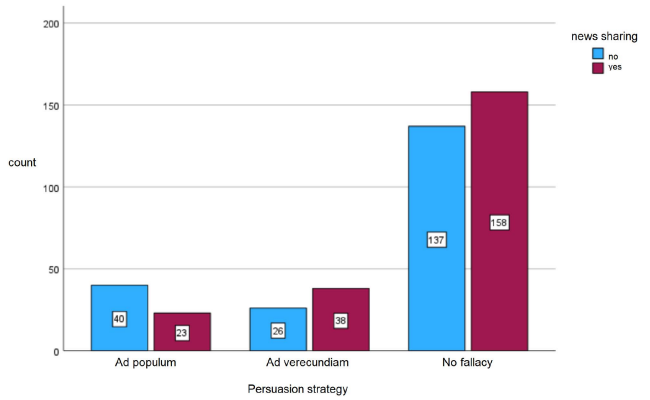

Fig. 6. Relationship between the presence of different types of fallacies and news posting.

news, containing no fallacies.[18] These figures are similar to those collected in phase 2.2, i.e., after an in-depth analysis, when 63 (29%) users posted news containing fallacies and 158 (72%) users posted "neutral" news. On the other hand, the number of news items shared in phase 3.1 is higher, with 189 (86%) users posting "neutral" news and 122 users (55%) posting "fallacious" news.

To understand whether the presence of logical fallacies impacted users' perception of news and, consequently, their posting behavior, we carried out a series of comparisons using the Chi-squared test, which can be used to determine if there is a relationship between two categorical variables. In particular, we analyzed news from phase 1.2, when users make an at-a-glance decision on news posting, since logical fallacies are more likely to affect scenarios where factors other than logical reasoning come into play. The relationship between the presence of fallacies (possible levels: yes, no) and news posting (possible levels: yes, no) was not significant, $\chi^2(1, N = 422) = 0.873, p = 0.35$, meaning that news with fallacies are as likely to be posted as news with no fallacies (see Fig. 5).

These somewhat unexpected results might have been influenced by the fact that the distribution of news with and without logical fallacies was not balanced. In fact, the number of news containing fallacies summed up to only 30% of the total number of news items included in the game sessions. Therefore, we cannot exclude that, since the number of fallacious news was smaller, their individual characteristics (such as topic, style, etc.) may have had a greater impact than the mere presence of fallacies, thus acting as a confounding variable.

On the other hand, considering only fallacious news, the distribution of items containing the *ad populum* fallacy (63 items) and the *ad verecundiam* fallacy (64 items) is very well balanced. Fig. 6 suggests that the *ad verecundiam* fallacy might have had a greater influence on the participants' choice of posting news. In fact, 38 users decided to post a news item containing the *ad verecundiam* fallacy, while only 23 users posted a news item including the *ad populum* fallacy. To assess whether the observed difference is significant, we conducted an additional Chi-squared test considering only fallacious news and using news posting (possible levels: yes/no) and the type of fallacy (*ad populum/ad verecundiam*) as variables. In this case, the relationship between these variables is significant, $\chi^2(1, N = 127) = 6.651, p = 0.01$, meaning that news with the *ad verecundiam* fallacy were more likely to be posted than were news with the *ad populum* fallacy.

This finding is of particular interest for a twofold reason. First, previous works in the contexts of traditional content recommendations, diffusion, and suggestions found (in different domains) that the *argumentum ad populum* was not effective [36], [37], [38], [39]. While confirming this overall results, our case study, on the other hand, also showed a minimal level of efficacy of this technique if compared with a subset of the previously mentioned works [38], [39] sharing a more similar, controlled, testing condition directly comparable to the one presented in this study (i.e., based on the use and evaluation of such technique with in presence interaction experiments rather than by estimating its impact on large-scale aggregated data). In such studies, in fact, the adoption of the *ad populum* was never successful (i.e., anytime it was employed, it received zero conversions). On the other hand, in our case study (to the best of our knowledge, the first targeting teenagers by explicitly exploiting such technique), 23 users posted a piece of news triggered by such a technique, thus suggesting that, even if not relevant, the potential influence of such a technique may be not zero. Second, the registered major persuasive efficacy of the *argumentum ad verecundiam* compared to the *argumentum ad populum* confirms results already reported in different domains, i.e., in web and mobile e-commerce in [38] and in human–robot interaction in [39]. Therefore, overall, these two findings, if grouped together, could suggest the hypothesis that young population (i.e., the target of our study) could be more prone to be influenced by fallacy-based techniques compared to older population (i.e., the targets of all the previously mentioned studies). However, in order to assess the latter speculative hypothesis, it would be necessary to set up a more concrete and robust comparative study that is out of the scope in the present contribution.

[18]Percentages do not sum up to 100% because each student could post up to three news items.

V. Discussion, Limitations, and Future Works

By and large, the evaluation study findings reveal that the game was effective in engaging players and in developing knowledge about fake news, as suggested by the GUESS results. In this sense, the game builds on effective design principles for educational games, which we briefly recounted in Section II, such as offering cognitive challenges [40] (i.e., identifying fake news from their title and description) and goal clarity [18] (which has been highlighted in GUESS questionnaire). The game also offered a familiar activity (i.e., the emulation of news sharing on social networks) for the players, likely facilitating the learning curve of the game, as suggested by Laine and Lindberg [18]. Moreover, the platform provided both players and teachers with clear feedback [41], which could be discussed in the classroom enabling moments of reflection, which is essential for the learner to become aware of her errors and facilitate her to acquire the required knowledge [42].

Some limitations should be taken into account concerning this study. As we noticed in Section III, our activity was designed with the intention of providing teachers from secondary school with a tool to deal in the classroom with the subject of analyzing content. This educational/scholastic purpose strongly conditioned the design and posed some strong constraints. First, despite the fact that our game can be played on both desktop PCs and smartphones, in schools, it has and will be used mainly on desktop PCs. Moreover, we have decided not to represent typical social context information (such as likes and comments) because these elements are source of distraction from the main educational task, especially for the age group in question, as already noted in some previous experiments [19]. Finally, for the sake of safety, our activity can be carried out without consulting other sources and without navigating outside the application: as a future work, the use of the platforms for the collection, detection, and analysis of online misinformation can be a useful extension and complement to our proposed analysis [43].

Students might need more practice before they can transfer what they learned to the real world: a future investigation should concern long-term effectiveness of interventions based on our games.

Another very relevant aspect to be analyzed is the opinion of the teachers who use our game to design educational interventions on the topic of fake news. In addition to the degree of satisfaction of the teachers, we want to analyze the scalability and applicability of our game for large-scale interventions outside the experimental context.

As for the instruments we chose to assess usability and user experience, we are aware that several other options are available, and that the use of different scales might provide further useful insights. A notable case in point is the MEEGA+ Game Quality Scale [44], which allows us to analyze educational games from the point of view of player experience and perceived learning, focusing on dimensions that basically overlap with those investigated through our questionnaires. However, there are two main reasons why we opted for different instruments. First, the MEEGA+ Game Quality Scale was primarily developed by having in mind students in the context of undergraduate computing courses, a target population different from ours (i.e., younger students attending secondary schools). Second, it is meant to classify educational games in a quality level according to an overall score (similarly to the SUS scale): since it also includes the social interaction dimension, which is not relevant for the Social4School platform (see Section IV-A1), we opted for alternative instruments, which allow us to use subscales independently. On the other hand, however, the MEEGA+ Game Quality Scale offers the possibility to define customized items to assess the attainment of game-specific learning outcomes: while this aspect was out of the scope of this article, we are planning to deal with it in future work, taking inspiration from the proposal of Petri et al. [44] to evaluate perceived learning.

VI. Conclusion

In this article, we have presented an online gaming platform providing a safe environment for supporting teachers in making educational activities on fake news more engaging and pleasant. An interface simulating a social media is used all along the activity, and a fake browser is used for analyzing some visual and style aspects of the news articles, including the title, the body, the URL, and the text. The news articles, created by the team, were intentionally written by inserting some rhetorical devices called fallacies. The game has been tested in several Italian schools and the level of usability and engagement of the serious game have been assessed through standardized surveys, and the aggregated behavior of the students during the game has been analyzed. The results show the suitability of the platform in providing a valuable tool for supporting educational activities on fake news analysis. The same test has highlighted some limitations of the approach that have been deeply investigated and will be addressed in our successive efforts to improve our platform in view of the public release of the game. In fact, as other games presented within our online environment, the online tool will be made available to all Italian schools and teachers free of charge. Due to the public it is addressed to, our platform is entirely in Italian; however, we also plan to open new collaborations with other research and didactic teams in Europe to support the development of localized versions of the game.

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Sara Capecchi received the M.Sc. degree from the University of Florence, Florence, Italy, in 2002, and the Ph.D. degree from the Department of Computer Science, University of Florence, in 2006, both in computer science.

Since 2010, she has been an Assistant Professor with the Department of Computer Science, University of Turin, Turin, Italy. Her main research interests include computer science education, conceptual models for trust and reputation systems, and static analysis of distributed systems with a focus on information leakage and access control.

Antonio Lieto received the Ph.D. degree in communication sciences (technology curriculum) from the University of Salerno, Salerno, Italy, in 2012.

He is an Associate Professor of Computer Science with the Department of Political, Social, and Communication Sciences, University of Salerno, Fisciano, Italy, where he leads the Cognition Interaction and Intelligent Technologies Lab. He is also a Research Associate with the Institute for High Performance Computing and Networking, Institute of the National Research Council, Palermo, Italy. He has authored the book titled *Cognitive Design for Artificial Minds* (Routledge/Taylor & Francis, 2021). His main research interests include commonsense reasoning, language and knowledge technologies, cognitive architectures for intelligent interactive agents, and persuasive technologies.

Dr. Lieto was the recipient of the Outstanding BICA Research Award from the Biologically Inspired Cognitive Architecture Society, USA. He was the Vice-President of the Italian Association of Cognitive Sciences from 2017 to 2022. He is an ACM Distinguished Speaker and a Member of the Board of the Italian Association for Artificial Intelligence.

Federica Patti received the Ph.D. degree in history of architecture and urban planning from Politecnico di Torino, Turin, Italy, in 2009.

She was a Councillor for Education and School Construction of the City of Turin from 2016 to 2019, the year in which she became a permanent guest, until 2022, in the Suburbs Group of the National Observatory for the Integration of Foreign Pupils and Interculture at the Ministry of Education. Since 2003, she has collaborated with the *Journal of Architecture* and writes articles and essays for Italian and foreign publications. She is an architect and technology teacher in secondary school. As an independent Researcher, she deals with and writes about topics related to school education and architecture.

Ruggero G. Pensa received the M.Sc. degree in computer engineering from the Politecnico of Turin, Turin, Italy, in 2003, and the Ph.D. degree in computer science from the Institut National des Sciences Appliquées de Lyon, Lyon, France, in 2006.

He is currently an Associate Professor with the Department of Computer Science, University of Turin, Turin. His main research interests include machine learning, data science, privacy-preserving algorithms for data management and mining, social network analysis, and spatiotemporal data analysis.

Dr. Pensa served in the Program Committee of many international conferences on data mining and machine learning, including IEEE International Conference on Data Mining, ACM International Conference on Information and Knowledge Management, SIAM International Conference on Data Mining, International Joint Conference on Artificial Intelligence, AAAI Conference on Artificial Intelligence, and European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases. He is a Member of the Editorial Board of *Data Mining and Knowledge Discovery* and *Machine Learning*. He was an Area Chair for the European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases and the International European Conference on Parallel and Distributed Computing.

Amon Rapp received the degree in communication in the information society and the Ph.D. degree in sciences of language and communication from the University of Turin, Turin, Italy, in 2006 and 2015, respectively.

He is an Associate Professor with the Department of Computer Science, University of Turin, Turin, Italy, where he leads the Smart Personal Technology Lab, Innovation for the Society and the Territory. He has authored more than 140 papers in international journals, such as *ACM Transactions on Computer-Human Interaction*, *Human–Computer Interaction*, *International Journal of Human–Computer Studies*, and *Computers in Human Behavior*, and peer-reviewed conferences, such as ACM Conference on Computer-Supported Cooperative Work and Social Computing, ACM Conference on Human Factors in Computing Systems, International Symposium on Wearable Computers/ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, and ACM Conference on User Modeling, Adaptation and Personalization. His research interests include human–computer interaction and the investigation of the effects of interactive and intelligent technologies on people's everyday lives.

Fabiana Vernero received the M.Sc. degree in communication in the information society and the Ph.D. degree in computer science from the University of Turin, Turin, Italy, in 2005 and 2011, respectively.

In 2012, she founded a startup in the mobile app industry, Sinbit, where she worked for several years as a Chief Experience Officer. She is currently an Associate Professor with the Department of Computer Science, University of Turin. Her research interests include human–computer interaction, intelligent user interfaces, recommender systems, and persuasive technologies.

Dr. Vernero served in the Program Committee of many international conferences on human–computer interaction, and intelligent systems, including ACM Conference on Intelligent User Interfaces, ACM Conference on User Modeling, Adaptation and Personalization, and ACM Recommender Systems Conference.

Sandra Zingaro is working toward the master's degree in communication, information and communication technologies, and media with the University of Turin, Turin, Italy.

She is a scholarship holder collaborating with the Department of Computer Science, University of Turin, on projects involving intelligent user interfaces, recommendation systems, and persuasive technologies.