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Using In-game Analytics to Explore Learning Dynamics of Information Literacy in a Social Media Simulator

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Abstract: The emergence of Game-Based Learning (GBL) strategies to promote critical thinking has generated a growing need for analytical tools able to assess their effectiveness. Current methods typically apply qualitative approaches such as focus groups and survey-based questionnaires evaluating players' knowledge, skills, and attitudes before and after playing the game; these methods are flexible, and they provide valuable information, yet new methods are needed to improve our understanding of what is happening during a gameplay session. The challenge of understanding the internal dynamics of GBL are illustrated by the open debate on gamified disinformation inoculators. These educational tools teach players how to identify disinformation by training them with a small set of fake news displayed within a gaming experience. There is an ongoing debate on what exactly is being learnt with these inoculators as some studies suggest a positive effect while other ones reveal that they promote scepticism instead of resistance against fake news. It is argued that new analytical methods are required to capture the learning process: detailed data collection on gameplay would be extremely useful to identify the most useful traits of Game-Based Learning, while detecting potential limitations or negative effects of this valuable learning resource. This work presents a novel framework to assess GBL dynamics grounded on data analytics. The approach uses the potential of the Unity in-game analytics platform to collect detailed data on how players tackle the challenges posed by the game mechanics; this diverse information may include the full set of decisions and interactions of the player as well as additional information such as the number of tries or time lapse between interactions. The behavioural data is then combined with content metadata information to infer general learning dynamics amongst players. This analytical framework is applied to a social media simulator included in the video game Julia: A Science Journey. Results suggest that the framework can reveal novel insights including aspects such as the level of engagement of the players, the impact of the type of content on the correct assessment of fake news, and the relation between reading speed and performance.

Keywords: Fake news, Video games, Data science, Information literacy, Critical thinking

1. Introduction

Digital games have become a widespread learning resource in formal education. The mix of narrative, interactivity, and problem-solving mechanics typical of this format can be easily applied to learning contexts to promote critical learning dynamics on complex scenarios involving a diversity of factors and processes. Additionally, playing video games generate a high level of agency which can be used to promote empathy towards life stories radically different than the personal experience of the students (Gee, 2014; McGonigal, 2011; Squire, 2011).

One of the main challenges of the emergent field of digital Game-Based Learning (GBL) is the assessment of educational strategies. The complexity of the interaction between a player and a digital game has no parallel in other formats and for this reason it is difficult to evaluate what has been learnt during a gameplay session (Connolly et al., 2009; Tahir and Wang, 2017). A range of previous works have applied qualitative approaches such as focus groups and documentary research which have been complemented by traditional survey-based methods comparing pre- and post- game skills and knowledge acquisition (Mayer et al., 2014). These studies are extremely valuable to better understand the learning outcomes of GBL yet several questions remain open to further methodological research. First, current methods do not explore the myriad of interactions developed during gameplay; the collection of detailed evidence on in-game player's behaviour may provide relevant insights on the strategies and solutions players devise to progress. Second, these methods are not well suited to capture the diversity of learning dynamics caused by the non-linear format of digital games; each player and gameplay will generate a different learning process because they will choose different actions in different orders. This non-linearity will not be captured by survey-based analysis once the session is over. Finally, these studies are almost exclusively developed in formal educational contexts because they need to collect feedback from the players outside gameplay while a majority of GBL processes happen outside the classroom. Consequently, informal learning dynamics can be hard to capture by these methods.

A session with any digital game is inherently a learning process even if it is not played in a formal context or the player is not consciously using gameplay as an educational resource. A player needs to acquire knowledge about the virtual world where the game develops as well as its story; if they want to develop a successful decision-making process then they also need to understand the goals of the game, to master its mechanics, and to plan based on the predicted consequences of their actions (Rubio-Campillo, 2020). From this perspective a large majority of GBL dynamics will happen in gameplay sessions at home and for this reason GBL studies also need methods applicable to these unsupervised experiences. The assessment of this type of informal learning sessions is always difficult due to their diversity and ubiquity within our daily routines (Galanis et al., 2016; Kerka, 2000; Livingstone, 2001; Vavoula et al., 2005). In the context of the video game industry there are hundreds of new commercial products published every year including content potentially useful for critical learning and formal education such as History, Archaeology, Biology, and Maths; however, the assessment of the learning outcomes achieved by these gameplay sessions is hardly possible. Therefore, millions of players are learning new skills and knowledge at a daily basis, but we do not know exactly what they are learning or to what extent these GBL dynamics are useful for educational goals beyond entertainment.

This work presents a novel research framework to study GBL dynamics based on the use of in-game data analytics and information visualization. The approach has been implemented in Julia: A Science Journey (JASJ), a digital game designed to promote critical thinking about the social impact of the COVID-19 pandemic. We present here the analysis of a minigame included in JASJ with the aim of promoting discussion on the use of social media and the impact of fake news in scientific knowledge. Next sections present the game and the fake news minigame while section four discusses the analytical framework implemented within the game. Section five discusses the results of the work, and the paper concludes with some thoughts both on the disinformation minigame and the use of the framework beyond this case study.

2. An overview of Julia: A Science Journey

The project DiHealthEd (2021-2022) was a research grant funded by the Catalan Research Agency (AGAUR) to use digital games to promote critical thinking on the impact of global emergencies within secondary education classrooms (DeJong, 2023; Fernández Galeote and Hamari, 2021; Squire, 2008). The main output of the project was Julia: A Science Journey (JASJ). JASJ was designed to be used in formal contexts and for this reason the game's contents were aligned with the Catalan secondary curriculum. JASJ was developed in 18 months by Murphy's Toast Games, a small, experienced studio specialized on transformative learning experiences (Rubio-Campillo, 2020; Rubio-Campillo et al., 2017). The game was released in Fall 2022, and it is freely available for Windows, Mac, and Linux operating systems both as a direct download and a Steam product since March 2023.

JASJ is structured in a set of episodes that can be independently played to facilitate use in 10-15 minutes sessions within the classroom which can be further enriched by a discussion supported by an Educator's Guide published in the game's website. The game can also be experienced in a conventional way with an average gameplay duration of two hours. Each of the episode depicts an animated scene, a dialogue, or a minigame focused on a specific topic such as science, the comparison between the COVID-19 and the 1918 Spanish flu pandemics, or the expectations of young adults towards their own future (see Figure **1**).

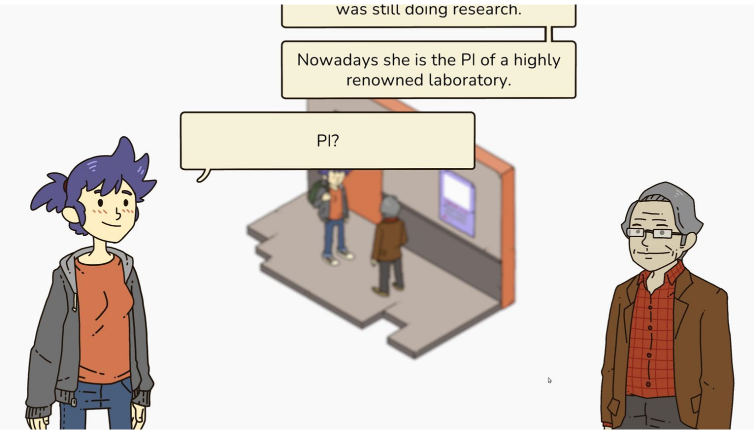

Figure 1: Storytelling in JASJ is developed through interactive dialogues

There are three types of minigames. The Presentation minigame is a metaphor for acquiring and communicating scientific information using two complementary mechanics: a) a quiz based on logical reasoning and curriculum content, and b) a platformer where difficulty is based on the player's performance in the previous quiz (see **Figure 2**). The Rider minigame is a cycling game designed as a reflection on the social climate and measures taken by different governments during the lock-down (e.g., wearing facemasks in open public spaces, see **Figure 3**).

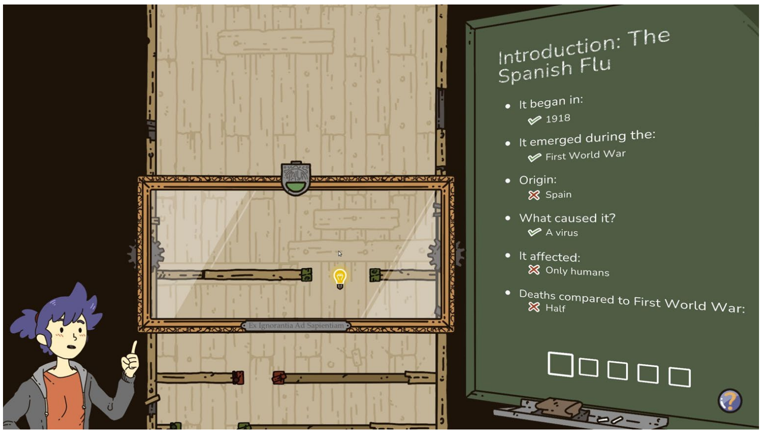

Figure 2: The Presentation minigame starts with a quiz including secondary curriculum content (right side); the rate of success in the quiz will define the difficulty of the platform level (left side)

Figure 3: The Rider minigame promotes discussion on the social dynamics caused by COVID-19 lockdown measures

Finally, the Quacker minigame simulates a Twitter-like social media network where users must report any Fake News shared in their wall. We discuss now this minigame as it will be used as a case study where explore GBL dynamics using in-game analytics.

3. Quacker: A Fake News Minigame

One of the current barriers to critical thinking on current global emergencies such as the COVID-19 pandemic and climate change is the growing presence of uncertain and false information shared via social media platforms. Social media engagement with controversial topics promotes a better understanding of their complexity yet approaching them require a solid understanding of scientific evidence, skills to prioritize information in digital contexts, and a key competence on identifying disinformation (Jiménez-Liso et al., 2020). An innovative strategy to train these skills is based on the concept of inoculation: if an individual learns how to identify fake news within a controlled context, then they will be able to perform the same task in real conditions. In this context, GBL is an ideal disinformation inoculator thanks to the use of interactivity and storytelling to present complex virtual scenarios (Lewandowsky and van der Linden, 2021). Quacker uses this approach to generate an educational interdisciplinary experience while reflecting on the social dynamics of the digital world by combining scientific content with themes such as mental health, toxicity, and popularity.

The Quacker minigame is integrated within the narrative of JASJ as it appears whenever the main character, Julia, is checking her phone. In this moment a new UI is shown displaying an app like twitter as can be seen in **Figure 4**.

Figure 4: Quacker is a social media simulation where users need to report fake news

Quacker's user experience has three main components: a) a short text message posted by a user (i.e. a quack), b) three possible reactions to the quack to be chosen by the player (report a fake new, like, or dislike), and c) two game stats: Julia's mood (i.e. mental health) and number of users (i.e. popularity). Each quack is internally coded with three variables: a) a Boolean variable defining if the quack is fake news, b) its level of toxicity, and c) its impact on Julia's popularity. The goal of the game is to react to 10 quacks while reporting fake news and balancing Julia's stats. On the one hand, the player needs to report all fake news while avoiding false reports; three strikes will end the game, thus forcing the player to replay the game with 10 different quacks. On the other hand, the toxicity of a quack will affect Julia's mental health while its content will change the number of her followers; the decrease of any of these stats below a certain threshold will become a failed state and force a replay. If the player can react to 10 quacks while avoiding this fail conditions, then they will receive a score of 1 to 3 stars based on performance. These game over and success screens also display ironic messages discussing the concepts of popularity and toxicity to reflect upon player's strategies (e.g., share controversial content to attract more attention).

Quacker is part of a growing amount of GBL approaches to disinformation inoculation which seem ideally suited to promote critical interdisciplinary thinking (DeJong, 2023). However, the effectiveness of the approach is still open to debate as recent works suggest that fake news inoculators promote scepticism instead of disinformation inoculation (Modirrousta-Galian et al., 2023); these unequal results suggest that the field needs larger sample sizes and better analytical methods to improve our understanding of how a player learns to identify fake news. The strategy deployed in JASJ was the development of in-game analytics designed to improve our understanding on the learning pathways followed by players across the gaming experience.

4. Analytical Framework

In-game analytics are data-driven frameworks designed to collect and analyse player's performance and behaviour within a digital game (Su et al., 2021). The exploration of in-game data allows game studios to gain insights on the player's experience to identify issues, improve gameplay, or optimize monetization. Beyond these traditional uses, in-game analytics can also be used to assess the learning outcomes of serious and educational games either using data visualization or more formal evaluation processes (Alonso-Fernández et al., 2019; Callaghan et al., 2014; Cano et al., 2019; Hauge et al., 2014; Loh et al., 2015).

JASJ used the Unity Analytics framework to collect data on player's behaviour across gameplay sessions. The data collected during a Quacker run tracked variables such as the player's reaction to every quack, the amount of time spent before reacting, and a diversity of summary statistics (e.g., number of strikes, Julia stats, replays). Data collection begins with the creation of a list of Events using the Unity analytics dashboard. These events can be sent by the game to the Unity servers whenever required via the API functions designed for this task. Two events were defined to assess Quacker: a) Quack and b) QuackSummary. The first event provides information on how a player reacts to a quack by including common in-game stats (e.g. user ID, timestamp, platform) and custom fields such as a unique **identifier** for the quack that the player is interacting with; the **action** of the player which may have the value of like, dislike, and report; the stats of **popularity and toxicity** at the moment of this interaction; and the number of **strikes** (i.e. wrong fake news reports) at the moment of this interaction. The second event was submitted at the end of a Quacker run and provided summary information on the player's actions such as a unique **identifier** for the run; the final **score** after 10 quacks ranged from 1 to 3 stars; the fail/success state; and the stats of **popularity and toxicity,** and **number of strikes** at the end of the run. The published version of JASJ includes a diversity of events similar to the ones described here to assess a wide range of player's behaviour during sessions; this anonymous data collection was made explicit in the first screen of the game, so players are aware of the process.

The Unity Analytics framework allows the developers to access the recorded events using a variety of dashboard visualization and SQL queries. This last option was the one chosen by the authors to explore GBL dynamics in Quacker. Specifically, the analysis focused on three questions: a) to what extent are players engaging with Quacker?, b) what type of content is harder to assess?, and c) is there a relation between reaction time and performance? These topics were explored within informal learning contexts by collecting the complete list of events submitted during Quacker gameplay for a sample of over 112 players. The dataset collected a total of 3565 quack interactions of 436 runs excluding abandoned runs and communication errors.

5. Results

Figure 5 shows the time series of Quacker runs included in the dataset since the release of JASJ in Fall 2022. The increase on the number of runs during Spring 2023 is caused by the release of the game in the Steam platform which is the main digital distribution platform for PC games.

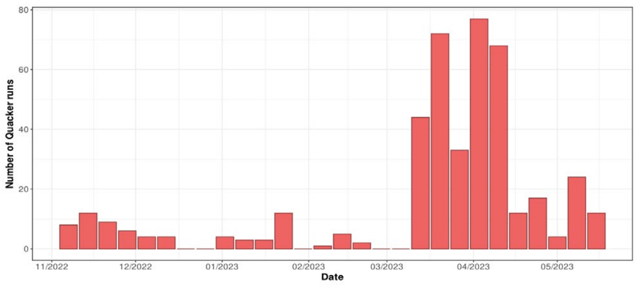

Figure 5: number of Quacker runs made by the sample of 112 players since September 2022 until April 2023.

The average number of runs per player is around 4 with a majority of users playing Quacker up to 3 times while a small number of players made over 10 runs. This replayability suggests a good level of engagement because users may continue with JASJ after the minigame even if their score is just 1 star (the minimum); a large percentage of players decided to continue playing until they achieved the best possible score of 3 stars while some players continued after getting a perfect score possibly to read all possible quacks (every run randomly displays 10 quacks over a pool of 30). This behaviour is independent of the type of player; most of the runs before Steam release were done by individuals who found the game through the science outreach portals where JASJ was advertised or received information shared by official social media accounts (e.g., University of Barcelona, Murphy's Toast Games). Once the game was released on Steam then the type of player changed towards gamers interested on narrative fiction and puzzles, yet the number of replays remained constant, thus suggesting a similar level of engagement.

The second question explored what types of social media content is more prone to be misclassified (i.e., fake news not being reported, and non-fake news being reported). **Figure 6** shows the percentage of player's reactions (report, like, or dislike) per quacks.

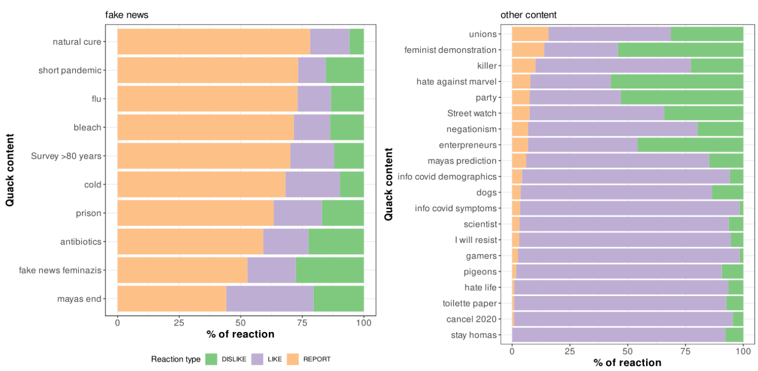

Figure 6: Percentage of player's reaction per quack; quacks are grouped by fake news/other content to facilitate comparison

Fake news more easily identifiable are the ones describing pseudoscience and false information linked to the COVID-19 pandemic (e.g., comparison between COVID-19 and flu). In contrast, disinformation related to political opinions has a higher rate of misclassification. For example, Figure 7 shows a quack linking International Women's Day marches with COVID-19 outbreaks which was incorrectly classified as a fact by over 50% of the players. The same pattern is seen in the opposite direction if at a lesser degree: quacks with facts mixed with political content were often misclassified as fake news for 10% of players.

Figure 7: Disinformation linked to political opinions such as feminism is more prone to be misclassified as facts

The analysis also suggests that players use the source of the quack as a proxy to prioritize information. In the minigame each quack includes a username and an avatar that the player can use to identify its source. Information provided by the World Health Organization was typically liked and not reported while similar content shared by suspicious accounts (e.g., individuals, associations against science) were reported even when they were opinions and not false information. Finally, quacks with content unrelated to politics (e.g., songs, jokes) were liked by most players.

The third question focused on the time players spent reading the quack and thinking before reacting to its contents. **Figure 8** reveals that how fake news and quacks with controversial opinions (e.g., political ideas, toxic messages) generated higher engagement rates as they spent more time before deciding how to react. Jokes and neutral content such as music lyrics required lower reading times before decision as players liked them to improve their game stats once they quickly decided not to report the content as disinformation. These results suggest that reading times are positively correlated to the complexity of the content which suggest an effective interaction between the player and the game; in fact, higher levels of engagement on complex or controversial social media content was one of the main expected learning outcomes defined during the design of Quacker.

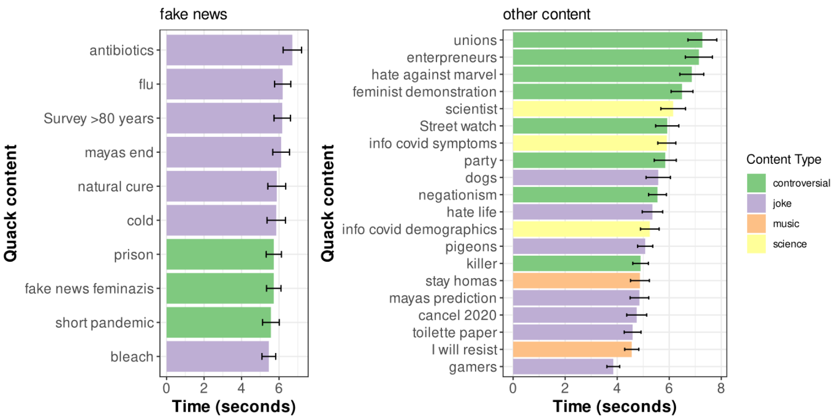

Figure 8: Average and standard deviation values for reading time per quack. Each quack is coloured by its type to facilitate comparison

This interpretation is enriched by **Figure 9** which displays the average reading time in a run compared to its final score. A negative correlation can be observed between player's performance and reading time as runs with higher scores display shorter reading times which equal roughly 50% difference between failed attempts and runs achieving the highest score (3 stars).

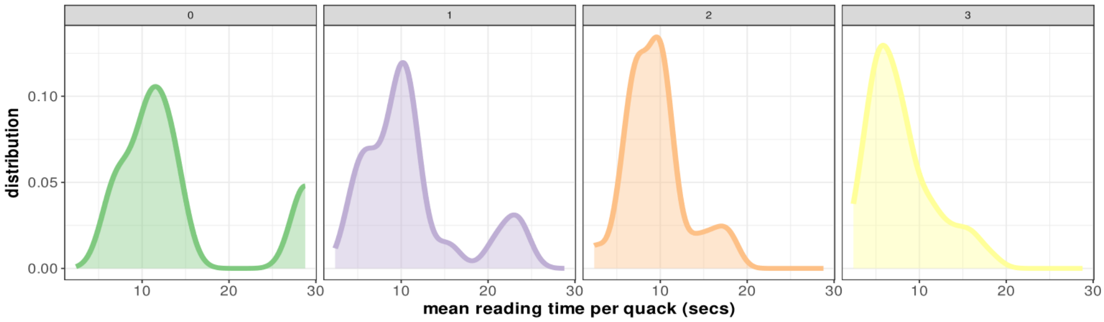

Figure 9: Density distribution of reading time per each score (0=game fail, 1 to 3 stars)

This pattern suggests that reading comprehension is linked to reading speed which is a working hypothesis currently subject to debate particularly in digital environments (Dyson and Haselgrove, 2000; Ekasari, 2021). An alternate plausible hypothesis is that players with higher levels of engagement repeated runs to improve their early scores, thus learning how to quickly identify disinformation and decreasing average reading time. Further research will be needed to explore the full learning process to better understand how players learn how to identify disinformation in social media contexts.

6. Conclusion

The data-driven analytical framework deployed in JASJ has revealed interesting insights on how players assess disinformation within controlled environments such as the Quacker minigame. The wealth of data collected from in-game player's behaviour allows researchers to study dynamics challenging to capture by other methods as exemplified by the combined analysis of reading times, type of content, and final performance. In-game analytics approaches can also be enriched by pre- and post-game surveys and player's feedback gathering which may even be integrated within the same game; in fact, JASJ includes an initial survey collecting anonymous information on the previous gaming experience of users which will be used in further studies in combination with in-game behaviour.

This work also shows the advantages of using tailor made digital games over commercial non-educational games as learning resources; the collection of in-game analytics is only possible if researchers have access to the development team because events must be called from the source code of the game. This is a limitation for initiatives willing to use commercial games as their main learning resource; this issue can be mitigated by the creation of mods collecting in-game data whenever possible (Yee, 2014), but the level of detail data will hardly be achieved by these technological solutions.

GBL strategies have proven to be an asset for learning complex scenarios by using the mix of narrative and interactivity that defines the gaming format. The increasing number of existing GBL experiences require a similar growth of analytical methods able to cope with the complexity of digital games. These techniques are already available to developers even if the original goals for in-game analytics have nothing to do with educational research. This paper has exemplified how these tools can be used within a data-driven analytical framework particularly suited to study GBL dynamics in unsupervised informal contexts. Ultimately, we hope that the analytical framework deployed in JASJ can contribute to a better understanding of the full complexity, diversity, and richness of GBL experiences within and beyond the classroom.

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References

Alonso-Fernández, C., Calvo-Morata, A., Freire, M., Martínez-Ortiz, I., Fernández-Manjón, B., 2019. Applications of data science to game learning analytics data: A systematic literature review. Computers & Education 141, 103612. https://doi.org/10.1016/j.compedu.2019.103612

Callaghan, Mj., McShane, N., Eguiluz, A.G., 2014. Using game analytics to measure student engagement/retention for engineering education, in: 2014 11th International Conference on Remote Engineering and Virtual Instrumentation (REV). Presented at the 2014 11th International Conference on Remote Engineering and Virtual Instrumentation (REV), IEEE, Porto, Portugal, pp. 297–302. https://doi.org/10.1109/REV.2014.6784174

Cano, A.R., Garcia-Tejedor, A.J., Alonso-Fernandez, C., Fernandez-Manjon, B., 2019. Game Analytics Evidence-Based Evaluation of a Learning Game for Intellectual Disabled Users. IEEE Access 7, 123820–123829. https://doi.org/10.1109/ACCESS.2019.2938365

Connolly, T., Stansfield, M., Hainey, T., 2009. Towards the development of a games-based learning evaluation framework, in: Games-Based Learning Advancements for Multi-Sensory Human Computer Interfaces: Techniques and Effective Practices. IGI Global, pp. 251–273.

DeJong, S., 2023. Playing With Fake News: State Of Fake News Video Games. IJGSI 1, 94–111. https://doi.org/10.24140/ijgsi.v1.n1.05

Dyson, M., Haselgrove, M., 2000. The effects of reading speed and reading patterns on the understanding of text read from screen. J Res in Reading 23, 210–223. https://doi.org/10.1111/1467-9817.00115

Ekasari, I.N., 2021. The correlation of reading speed and reading comprehension in xreading. RETAIN (Research on English Language Teaching in Indonesia)(e-Journal) 9, 51–57.

Fernández Galeote, D., Hamari, J., 2021. Game-based Climate Change Engagement: Analyzing the Potential of Entertainment and Serious Games. Proc. ACM Hum.-Comput. Interact. 5, 1–21. https://doi.org/10.1145/3474653

Galanis, N., Mayol, E., Alier, M., García-Peñalvo, F.J., 2016. Supporting, evaluating and validating informal learning. A social approach. Computers in Human Behavior 55, 596–603. https://doi.org/10.1016/j.chb.2015.08.005

Gee, J.P., 2014. What Video Games Have to Teach Us About Learning and Literacy (Second Edition). MacMillian.

Hauge, J.B., Berta, R., Fiucci, G., Manjon, B.F., Padron-Napoles, C., Westra, W., Nadolski, R., 2014. Implications of Learning Analytics for Serious Game Design, in: 2014 IEEE 14th International Conference on Advanced Learning Technologies. Presented at the 2014 IEEE 14th International Conference on Advanced Learning Technologies (ICALT), IEEE, Athens, Greece, pp. 230–232. https://doi.org/10.1109/ICALT.2014.73

Jiménez-Liso, M.R., González-Herrera, M., Banos-González, I., 2020. Socio-Ecological Controversies in the News as Trigger of a Model-Based Inquiry Instructional Sequence about the Effect of Global Warming on the Great Barrier Reef. Sustainability 12, 4676. https://doi.org/10.3390/su12114676

Kerka, S., 2000. Incidental Learning. Trends and Issues Alert No. 18. ERIC.

Lewandowsky, S., van der Linden, S., 2021. Countering Misinformation and Fake News Through Inoculation and Prebunking. European Review of Social Psychology 32, 348–384. https://doi.org/10.1080/10463283.2021.1876983

Livingstone, D., 2001. Adults' Informal Learning: Definitions, Findings, Gaps, and Future Research., in: New Approaches to Lifelong Learning NALL, Working Paper# 21. Ontario Institute for Studies in Education, University of Toronto, Toronto.

Loh, C.S., Sheng, Y., Ifenthaler, D. (Eds.), 2015. Serious games analytics: methodologies for performance measurement, assessment, and improvement, Advances in Game-Based Learning. Springer, Cham; Heidelberg. https://doi.org/10.1007/978-3-319-05834-4

Mayer, I., Bekebrede, G., Harteveld, C., Warmelink, H., Zhou, Q., van Ruijven, T., Lo, J., Kortmann, R., Wenzler, I., 2014. The research and evaluation of serious games: Toward a comprehensive methodology: The research and evaluation of serious games. Br J Educ Technol 45, 502–527. https://doi.org/10.1111/bjet.12067

McGonigal, J., 2011. Reality is broken: Why games make us better and how they can change the world. Penguin.

Modirrousta-Galian, A., Higham, P.A., Seabrooke, T., 2023. Effects of inductive learning and gamification on news veracity discernment. Journal of Experimental Psychology: Applied. https://doi.org/10.1037/xap0000458

Rubio-Campillo, X., 2020. Gameplay as Learning: The Use of Game Design to Explain Human Evolution, in: Hageneuer, S. (Ed.), Communicating the Past in the Digital Age: Proceedings of the International Conference on Digital Methods in Teaching and Learning in Archaeology (12th-13th October 2018). Ubiquity Press, pp. 45–58. https://doi.org/10.5334/bch.d

Rubio-Campillo, X., Caro Saiz, J., H. Pongiluppi, G., Laborda Cabo, G., Ramos Garcia, D., 2017. Explaining archaeological research with videogames: The case of Evolving Planet, in: Mol, A., Ariese-Vandemeulebroucke, C., Boom, K., Politopoulos, A. (Eds.), The Interactive Past: A Book on Video Games and Archaeology. Sidestone Press, pp. 153–166.

Squire, K., 2011. Video games and learning. Teaching and participatory culture in the digital age. New York, NY: Teachers College Print.

Squire, K.D., 2008. Video games and education: Designing learning systems for an interactive age. Educational Technology 48, 17.

Su, Y., Backlund, P., Engström, H., 2021. Comprehensive review and classification of game analytics. SOCA 15, 141–156. https://doi.org/10.1007/s11761-020-00303-z

Tahir, R., Wang, A.I., 2017. State of the art in game based learning: Dimensions for evaluating educational games, in: European Conference on Games Based Learning. Academic Conferences International Limited, pp. 641–650.

Vavoula, G., Sharples, M., Scanlon, E., Lonsdale, P., Jones, A., 2005. Report on literature on mobile learning, science and collaborative acitivity.

Yee, N., 2014. The Proteus paradox: How online games and virtual worlds change us-and how they don't. Yale University Press.