

Designing Limes Text: Adapting an Educational Video Game into a Text-Based Format for Controlled Experimental Comparisons

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Abstract: Comparing educational video games and text-based learning presents a significant challenge when trying to ensure a fair comparison between the two formats. Their distinct natures, particularly in terms of engagement and interactivity, introduce uncontrolled variables that are often not directly comparable between a video game and a text. Many prior studies rely on static text conditions that do not account for reader engagement, decision-making, or interaction patterns. This paper therefore proposes a structured game design approach to developing a text-based application that enables a more precise and controlled comparison with video game-based learning. *Limes* is a 2D educational video game set in Roman frontier Germany, designed to teach historical knowledge through exploration and interactive learning elements. The game features a structured narrative, Codex entries with historical information, and secondary missions, all contributing to the player's engagement and learning experience. The text version of *Limes* is not a game but replicates key gameplay characteristics in a structured text-based format, providing an alternative to traditional text conditions in experimental research. Unlike passive reading conditions, this Text-app is designed to be interactive and engaging in the same ways as its video game counterpart. Moreover, like the video game, the Text-app tracks player behaviour, such as time spent reading, engagement with Codex entries, and whether secondary mission texts have been read, using a five-star rating system mirroring the game's assessment mechanics. The present paper discusses the development of the *Limes* Text-app and presents a game design framework for adapting educational games into experimentally viable text-based counterparts. The contribution is particularly relevant to research on video game effects in education adopting experimental designs. However, beyond its experimental utility, the newly developed text-app offers promising opportunities for other research areas, and we discuss how it can, for example, be used to assess and explore digital traces of learner characteristics and behaviours. To conclude, by ensuring structural comparability and capturing interaction data across formats, the *Limes* Text-app addresses a key methodological challenge in video game-based learning research: the difficulty of creating valid text-based control conditions that enable meaningful comparisons. While *Limes* has been developed in the context of history education, the impact is much broader as our design framework is adaptable and could be extended to other domains and narrative-based games.

Keywords: Game design, Text-Based learning, Educational gaming, History education, Experimental methodology

1. Introduction

Over the past two decades, educational video games have gained increasing recognition for their potential to enhance learning outcomes, particularly by fostering engagement, motivation, and deep cognitive processing (Wouters *et al.*, 2013; Clark, Tanner-Smith and Killingsworth, 2016; Ren, Xu and Liu, 2024). This growing body of research has resulted in numerous experimental comparisons of video game-based learning with more traditional learning methods, most commonly text-based formats. However, these comparisons often suffer of methodological limitations related to structural differences between formats, particularly the use of passive text conditions (e.g., slideshows or static PDFs) that lack interactivity, decision-making, or behavioural tracking—an issue repeatedly flagged in systematic reviews (Wouters *et al.*, 2013; Riopel *et al.*, 2019; Gui *et al.*, 2023). These limitations can undermine experimental validity, as they make it difficult to determine whether observed effects and differences between formats are due to the format itself or to differences in interactivity and design features (All, Castellar and Looy, 2014).

For example, Gutierrez *et al.* (2014) compared a video game aiming to promote perspective-taking with a text version of the same story. Even though the content was identical, the two conditions differed fundamentally in structure, and only the game offered interactivity and decision-making. The findings of the study revealed that the game condition led to reductions in implicit bias; nonetheless, given the differences between the conditions, it was impossible to disentangle whether the format (game versus text) or other features (interactivity and decision-making, which was only possible in the game condition) drove the effects. This also highlights how even content-equivalent text formats can fail to replicate the mechanisms through which games operate. More recently, Lee and Chen (2023) found that while both game and text interventions had a positive effect on intergroup attitudes, only the game condition allowed for tracking of user behaviour—a key limitation in the passive text condition, which offered no insight into decision-making, time-on-task, or interaction patterns.

Gui et al. (2023), drawing on Mayer's (2015) framework, classify most digital game-based learning (DGBL) studies into two main types: media comparison studies—which contrast games with traditional formats such as text or lectures—and value-added studies—which compare different versions of a game to isolate the effects of specific design elements (e.g., feedback, adaptation). While Gui et al. (2021) do not focus directly on control group design, they emphasise that meaningful comparisons require attention to how learners interact with design elements rather than focusing solely on the delivery format. This perspective reinforces the need for structurally comparable experimental conditions that can capture user behaviour and engagement, even in non-game formats.

The methodological issue of comparing game versus text became evident during the design of our experimental studies, which involved *Limes*, a 2D educational adventure game set in ancient Roman times in Germany (see Viccari et al., 2024, for a description of the game development). The initial idea for the control group was to read a simple PDF version of the game's story. However, it quickly became apparent that the limitations of this format did not allow a valid comparison with the video game. Also, key behavioural measurements that can be accessed during the gameplay of *Limes* cannot be equally measured with a standard PDF file. For example, crucial points for our research include tracking and measuring the selection of optional Codex entries, exploratory decisions—specifically, the accomplishment of the secondary missions—and a five-star rating system for level accomplishment, which are central to the *Limes* gameplay experience.

In response to these issues, we developed a structured, interactive text-based application built in Unity that replicates the game's narrative structure, meant to track and measure the key game mechanics mentioned above. This Text-app represents a novel approach to control group design in video game-based learning research, one that ensures a functional comparison between a text and a video game, allowing researchers to hold specific key mechanisms constant across the two formats.

This design paper presents the process and the decision-making behind the development of the *Limes* Text-app and proposes a framework for converting educational video games into interactive text-based counterparts. By addressing the limitations of passive text control conditions, this paper offers a methodological contribution to the field of experimental educational research. Through this framework, we aim to provide a foundation for more valid and controlled comparisons between video games and text-based learning formats, ensuring that differences in outcomes can be more confidently attributed to format effects.

2. How to Convert a Video Game into Text

2.1 The Game

*Limes*¹ is a 2D educational video game developed in Unity and designed for 5th and 6th-grade students in Germany, focusing on Roman history. The video game story is set in third-century southern Germany; the game follows the journey of an Alemanni child and a Roman centurion named Ariovist in a period where the tensions between the Roman Empire and the Alemanni, a prominent Germanic tribe, are rising. The narrative is structured across five levels; each level contains a main and a secondary mission that rewards players through a five-star rating system. Players can engage in varied game mechanics, including stealth, exploration, dialogue choices, horse racing, puzzle-solving, and rock-throwing.

Players can obtain a considerable amount of historical information from the dialogues presented during the main and secondary missions. However, an essential pedagogical feature is the Codex system, which allows players to access historical content embedded in the game world (Figure 1). These entries are unlocked through interaction with the Non-Playable-Characters (NPCs) (Figure 1), providing deeper context and more historical information about the Roman period. These behaviours are also trackable, providing researchers with crucial behavioural information, such as interactions with the codex entries, the accomplishment of secondary missions, and time-on-task tracking. The video game has been designed with input from history education, psychology, and game-based learning principles; *Limes* aims to foster historical knowledge, positive diversity beliefs, and motivation through a narrative-driven, interactive experience (Viccari et al., 2024).

¹ The *Limes* video game can be accessed at: <https://ancient-verse-research.itch.io/limes> (Windows and Mac versions available).

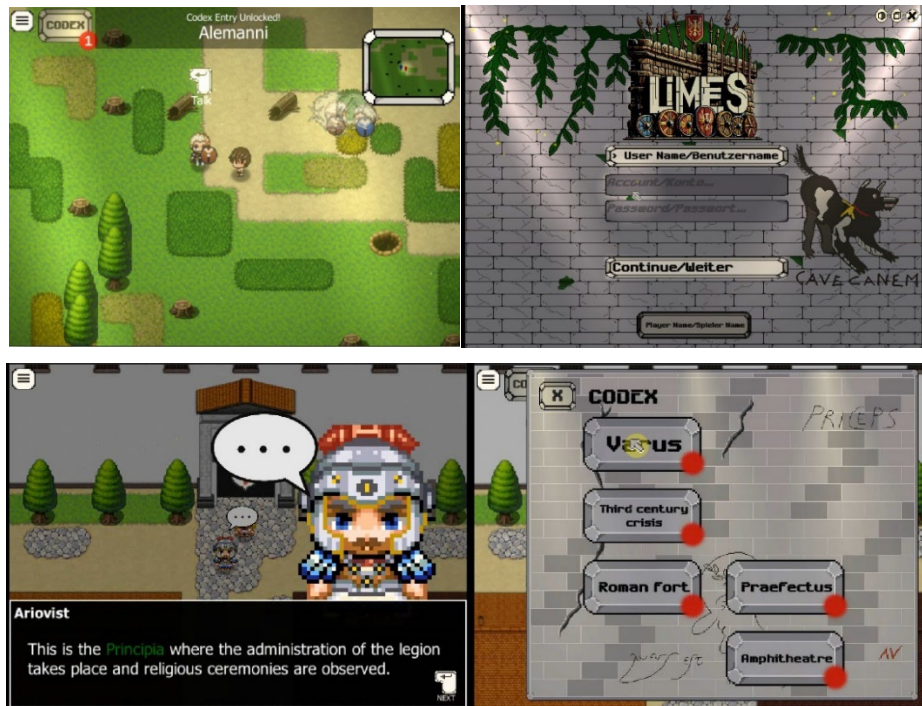


Figure 1: (Top-left) Gameplay screenshot in *Limes* video game. (Top-right) Login screen of the *Limes* video game. (Bottom-left) An example of a Codex entry being unlocked during gameplay. (Bottom-right) The Codex menu shows unlocked entries during gameplay

2.2 Identifying Core Game Features for Adaptation

While educational video games may include various immersive and interactive elements, not all are essential—or feasible—for replication in a text-based format. Identifying the suitable mechanics in the *Limes* video game was a crucial stage in creating a comparable text-based control condition. It was decided to select features that support the intended learning outcomes and represent behavioural data relevant to the experimental study. The following elements were selected as core to the adaptation process.

Codex entries are a central mechanic in *Limes* (Figure 2), allowing players to read or hear historical information connected to in-game dialogues and explore Roman history in greater depth. The content was adapted for 5th and 6th-grade students, covering key topics from the school curriculum. These entries are optional and are unlocked through exploration or dialogue. Their inclusion is pedagogically significant, as they support factual knowledge acquisition and allow learners to engage with supplementary material at their own pace. As Mayer (2015) notes, narrative context and thematic relevance can enhance learner motivation and engagement. According to relevance-based reading models, learners are more inclined to engage with optional content if they find it meaningful (McCrudden and Schraw, 2007; McCrudden, Magliano and Schraw, 2010). For this reason, the text version needed to replicate both the availability of these entries and the ability to track interactions, specifically, how often they were accessed and how much time was spent on them.



Figure 2: Codex entry example during a gameplay in *Limes* video game

Secondary missions function as exploratory and additional side quests, allowing players to interact with additional narrative material, deepen their understanding of the game world, and access extra game mechanics, such as horse racing. These missions are optional, reflecting the player's autonomy in engaging with extended content. From a design perspective, they represent an opportunity to allow for learner agency, autonomy, and interest-driven behaviour, thus contributing to their self-determined motivation (Ryan and Deci, 2000; Dennie, 2012; Proulx, Romero and Arnab, 2017). In adapting the game into a text format, it was important to preserve this element of choice, allowing readers to decide whether to access the additional material while also enabling that choice to be tracked.

Time-on-task tracking was another essential feature that needed to be included in the text adaptation of *Limes*. In the original game, the Unity code records the amount of time spent on several sections and transfers that information to the Mongo Database—such sections are the main storyline, secondary missions, and Codex entries. Tracking time spent on different sections provides insight into learners' attention, engagement, and navigation behaviour within the *Limes* environment. Therefore, incorporating equivalent tracking in the text version was necessary to allow for behavioural comparison across conditions. This approach aligns with recent research advocating for objective behavioural tracking in digital environments, as it provides more accurate insights into user engagement than self-reported measures (Johannes, Vuorre and Przybylski, 2021).

The game's **five-star rating system** is an integrated assessment mechanism that evaluates performance based on exploration, completion of secondary missions, and Codex usage. This system is pedagogically relevant because it provides immediate, performance-based feedback, which has been shown to foster learners' satisfaction of their need for competence, and their motivation (Sailer *et al.*, 2017; Bardach and Murayama, 2025). Recreating this rating system in the Text-app was important to allow participants in both conditions to receive similar performance feedback and to maintain motivational comparability across formats.

Together, these four features—Codex interaction, secondary mission engagement, time-on-task in the different sections of the game, and the five-star feedback system—were identified as central to the pedagogical structure of *Limes* and critical for experimental comparability. Their inclusion in the text version was not an attempt to gamify the reading experience but rather to create a structurally aligned learning environment that would allow for meaningful behavioural tracking and outcome comparison in a controlled study.

2.3 Framework for Game-to-Text Adaptation

Challenges discussed earlier in the introduction highlighted the need for a control condition that goes beyond a static PDF or linear text, offering greater interactivity and measurability. Considering the experience gained while developing the *Limes* video game, we opted for a structured text application² using Unity. This allowed for precise segmentation of content and the implementation of custom tracking systems mirroring the logic of the game (Figure 3). The text was divided into three main types of content:

1. Main storyline,
2. Secondary missions
3. Codex entries

² *Limes* Text-app can be accessed at: <https://ancient-verse-research.itch.io/limes-version-2> (Windows and Mac versions available).

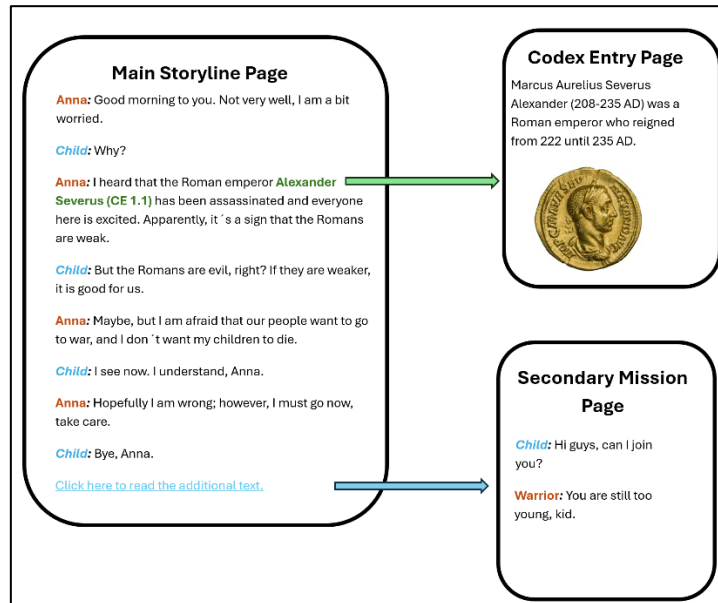


Figure 3: The diagram provides a simplified illustration of the Unity-based structure, showing how the main storyline connects to optional Codex entries and secondary missions, each displayed in separate text panels

Each section was implemented as an interactive module with automated time tracking and click logging.

The **main storyline** served as the structural backbone of the app and was set as the default view that loaded when the user launched the application. It was implemented as a scrollable text panel within Unity’s system, very similar to a regular PDF document, with time tracking initiated automatically upon scene load. Since all study participants are required to read the main story, this section provided the baseline to which optional interactions, like secondary missions and Codex entries, could be added.

Secondary missions, which were optional side quests in the game, were similarly adapted as clickable links embedded in the main narrative (Figure 4). These links appeared as light blue text at relevant decision points of the story, such as “Click here to read the additional text.”



Figure 4: (Left) additional text link in the Text-app, (right) secondary mission choices during the gameplay of Limes video game

When the link is clicked, the app records the interaction and the time spent on the additional text page(s). This enables precise measurement of engagement with optional content—an essential feature to support autonomy and potential indicator of learners’ interest.

Codex entries, another optional learning mechanic in the game, were embedded directly into the main narrative using the same green-highlighted format as in the original game (Figure 1). When clicked, each Codex entry opened in a dedicated window (Figure 5). As with the game counterpart, the system logged the time spent reading each entry and whether it had been accessed. All interaction data was stored in a Mongo Database, identical to the architecture used for logging gameplay behavioural data in *Limes*.

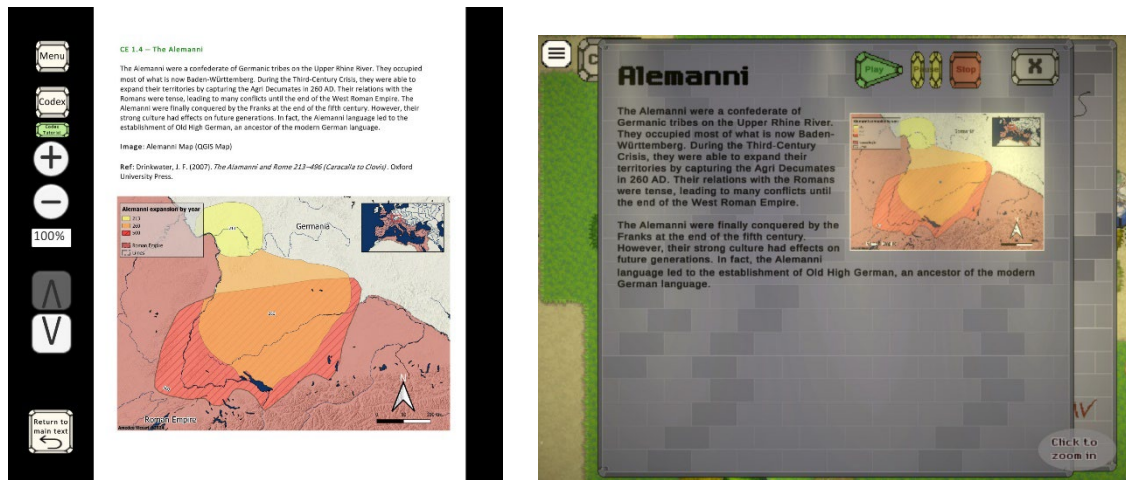


Figure 5: (Left) Codex entry example in the Text-app. (Right) Codex entry example in *Limes* video game

The five-star rating system was also implemented in the text version. This allows users to see their performance for each section of the text, equivalent to the levels in the game version. The performance is based on these actions:

- Clicking all Codex entries available in a text section.
- Access the additional text link corresponding to the secondary mission in the gameplay.

As in the game version, the Text-app requires users to complete the main storyline before receiving their star rating, which is displayed in a similar format to maintain consistency across the two media (Figure 6).

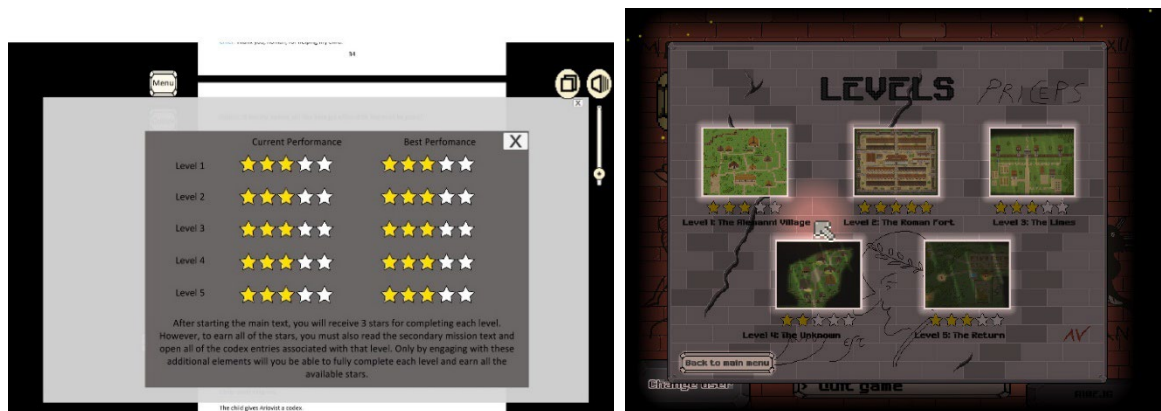


Figure 6: (Left) Five stars awarding system in the Text-app. (Right) Five stars awarding system in *Limes* video game

Another important aspect replicated in the Text-app is full access to the Codex entries once the main text has been completed. As in the game, all Codex entries become accessible at this point; however, accessing them after completing the main content does not affect the five-star rating—unless the reader revisits the corresponding text sections, just as players would need to replay levels in the game.

The Text-app preserves the same narrative and allows users to make similar decision options by clicking on additional text or the codex entries, while also enabling precise tracking of these behaviours. This approach is meant to establish a structurally aligned control condition, ensuring that any differences in learning outcomes are more likely connected to the format itself (game vs. text), rather than to variations in content structure, engagement features, or users' behaviours.

2.4 Early Testing and Feedback

As with the original *Limes* video game, the text-based application was tested with experts during development to gather formative feedback on content clarity and possible technical problems. These reviewers included educational researchers and historians familiar with the project's goals, as well as individuals experienced with digital learning tools.

Since the app was developed in both German and English, preliminary testing was conducted in both languages. However, special attention was given to the German version, as it was the version intended for use our first experiments. This included reviewing the linguistic accuracy of the texts and checking for fluency and user comfort when navigating the app's interface.

Feedback led to two main refinements. First, some dialogue passages and transitions were restructured slightly to better fit a linear reading experience, particularly in the German version. Second, the initial scroll system was unintuitive and slow, presenting several issues when combined with the navigation arrows. This resulted in delays and imprecise navigation through the text. To address this, the underlying code was adjusted to ensure smoother scrolling and to make the app interface more user-friendly. These changes significantly improved navigation fluidity across the main story, Codex entries, and secondary missions while preserving the behaviour-tracking structure required for the experiment.

A crucial aspect of the testing phase was verifying the interaction between the Text-app and the Mongo Database, where behavioural data, such as Codex clicks and time-on-section, is stored. The tests confirmed that the data was recorded accurately and reliably. While the video game and Text-app use separate MongoDB databases with different field names and structures, the underlying logic and data types are aligned. These differences are the results of the independent Unity development of the two applications. Both systems record the same core variables: time spent (in seconds), Codex interactions (number of clicks), star achievements per level, and secondary mission completion, see below:

<i>Mongo Database – Video game</i>	<i>Mongo Database – Text-app</i>
totalTimeLevel1: seconds	timeSpentMainText: seconds
totalTimeLevel2: seconds	timeSpentCodex: seconds
totalTimeLevel3: seconds	timeSpentSecondaryMission: seconds
totalTimeLevel4: seconds	codexEntryClicks: number of clicks
totalTimeLevel5: seconds	totalActiveTimeMainTextSecondaryMission: seconds
totalTimeMainSec: seconds	level_1_stars: number of stars
totalTimeCodexMenuOpen: seconds	level_2_stars: number of stars
codexButtonClicked: number of clicks	level_3_stars: number of stars
starsLevel1: number of stars	level_4_stars: number of stars
starsLevel2: number of stars	level_5_stars: number of stars
starsLevel3: number of stars	level_[level number]_secondary_star_awarded: Mission Achieved – true or false
starsLevel4: number of stars	
starsLevel5: number of stars	
CompletedSecondaryMissions: Object 1 (Mission Achieved)	

In the game, mission completion is logged as an object per level; in the Text-app, the same is recorded as Boolean values (true or false). Time tracking of the secondary missions is split in the Text-app for structural reasons but later merged—mirroring the unified level time in the game.

2.5 Limitations and Future Directions

While this paper does not report empirical results from experiments, its contribution lies in presenting a structured and trackable text-based format that enables more valid comparisons between video games and texts in experimental research. This constitutes, to the best of our understanding, the first attempt of its kind. Our paper provides a practical framework that other researchers can adapt or build upon when designing their own structurally aligned control conditions. While tailored to a narrative-driven history game, the framework may be transferable to other domains that rely on exploratory learning or decision-making, such as science simulations or cultural education. Its modular structure and tracking logic are adaptable to any learning context involving optional content, time-on-task, and user-driven exploration. Future work could explore how this framework performs when adapted to other domains (e.g., environmental science, language learning, or civic education), where narrative and autonomy also play key roles. Overall, our approach has the potential to inspire similar projects in other domains by showing how behavioural tracking and narrative structure can be replicated in non-

game formats. Future work will evaluate the empirical utility of this framework and examine how structural alignment, and behavioural tracking can support robust comparisons across different educational formats. In our own upcoming experimental studies comparing the *Limes* video game and the *Limes* Text-app, we aim to gain insights into the pedagogical effectiveness of such a Text-app compared to its game counterpart, particularly in terms of learning outcomes (e.g., knowledge on the Roman Empire), motivation, engagement patterns, and intercultural attitudes.

Beyond its applicability in experimental contexts, the newly developed Text-app opens up additional opportunities for future research. There is growing interest in educational and psychological research in modelling and assessing digital traces of learner characteristics and behaviours to test theories *in action* and inform practice. For example, researchers are exploring digital traces of educationally relevant personality traits and motivations, and use digital traces to predict outcome variables, such as test performance and knowledge attainment (e.g., Tlili *et al.*, 2019; Matcha *et al.*, 2020; Schumacher *et al.*, 2025). Exploring whether different learner characteristics are reflected in behavioural patterns captured by the *Limes* Text-app and the video game could yield valuable insights for research and offer practical implications for adaptive educational technologies. In addition to using the behavioural indicators described in the present design paper, researchers could also create new indicators to more comprehensively test their theoretical assumptions in future research with *Limes*. For instance, a recent study found some indications that intellectual curiosity (as a personality trait) and domain-specific interest (as a motivational construct) manifested in different information-seeking behaviours: interested learners employed a more widespread search for information, whereas curious individuals engaged more deeply with the learning content by revisiting information more frequently (Schumacher *et al.*, 2025). This distinction could be further investigated using *Limes*, for example, by analysing the revisiting of codex entries as a behavioural indicator.

3. Conclusion

This design paper introduced the development of a structured, interactive Text-app built as a control condition for experimental research comparing video game- and text-based learning formats in history education. The text application replicates the key pedagogical mechanics of the educational video game *Limes*—including time-on-task tracking, engagement with optional content, and a five-star feedback system—within a Unity-based environment that enables precise behavioural monitoring. By ensuring structural comparability and capturing interaction data across formats, the Text-app addresses a significant methodological challenge in video game-based learning research: the difficulty of creating valid text-based control conditions that allow meaningful comparisons. Even though the current project is tailored to Roman history and the *Limes* project, the framework is adaptable and could be extended to other domains and narrative-based games.

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Ethics declaration: Research on the *Limes* project has been approved by the ethics committee of the University of Giessen, Department of Psychology.

AI Declaration: AI tools were used in a supportive capacity during this project. Grammarly was used during the writing process to assist with grammar and style suggestions. GitHub Copilot was employed to support and accelerate the development of C# scripts for the interactive Text-App in Unity. All code was authored and reviewed by the first author, with Copilot assisting in suggesting possible changes. Additionally, OpenAI’s ChatGPT was, in some instances, consulted during the writing process for feedback on the structure of English sentences. All content decisions and final formulations were made by the authors.

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