

Learner-centered Design in Practice: The Impact of Non-learning Elements on Engagement and Learning Experiences

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Abstract: This paper presents the results of a comprehensive survey conducted on an educational game developed over three years following a learner-centred approach. The final evaluation involved 168 participants engaging with the game, providing both quantitative and qualitative data. Notably, the study found that integrating educational content with non-educational elements or exploratory features proved beneficial, enhancing both motivation and overall learning experiences. The learner-centric development cycle was pivotal in creating a balanced environment that fostered meaningful learning while maintaining engaging gameplay. Data collection included responses to a game experience questionnaire for quantitative analysis, alongside inductively categorised free-form text answers to capture qualitative insights. Participants reported overwhelmingly positive experiences with non-learning content and primarily positive feedback regarding learning components. These findings demonstrate that the inclusion of non-learning-related content can significantly contribute to a positive learning experience by increasing motivation and sustained interaction with educational tools. In addition, the vast majority of responses to the free-form learning survey were positive, further highlighting the beneficial impact of combining educational and non-educational elements to create a motivating and engaging learning environment. Furthermore, the data revealed that participants with existing competence in the relevant subject matter reported higher learning experiences, suggesting that practical application corresponding to the 'Apply' stage of Bloom's taxonomy may be particularly effective in the context of educational games.

Keywords: Educational games, Serious games, Game design, Education

1. Introduction

"A serious game is a digital game that was created with the intention to entertain and to achieve at least one additional goal (e.g., learning or health). These additional goals are named characterizing goals" (Dörner et al., 2016).

Educational games as a subset of serious games have emerged as a powerful tool in higher education, offering unique opportunities for students to actively engage with subject matter in simulated environments. Unlike traditional teaching methods, games enable learners to apply their knowledge dynamically, fostering deeper understanding through experiential learning.

Academic settings often emphasise theory or lack opportunities to apply learning in practice. Educational games address this by providing a curriculum-aligned environment where students can put theories into action.

The Analyst is an educational game developed to instruct students in human diagnostics by leveraging various motivational elements to enhance engagement and progression within the game. By fostering increased motivation to advance through gameplay, the design aims to promote greater participation with the learning materials presented.

2. Related Work

2.1 A Good Serious Game

To realize the potential of serious games, Bruder et al. (2021) introduced criteria for what constitutes a "good" serious game. Such a game must offer high quality in both its gaming elements and its "serious" components, but more importantly, there must be a meaningful connection between the two. This fit ensures that gameplay mechanics and the intended goals integrate seamlessly, rather than feeling like two separate applications. This

idea can be seen as an evolution of Sinclair et al.'s dual flow concept. Building on Csikszentmihalyi's well-known "flow" theory, the authors transform it into two distinct flows.

Csikszentmihalyi (1990) describes the flow state as complete immersion in an activity, where one loses awareness of time and space. Achieving this state requires a balance between the user's skill level and the challenge provided by the activity—which, in this context, is the game.

Sinclair et al. (2009) expand on this with their dual flow model, particularly in exergames. Here, one flow arises from engaging gameplay, while the other relates to the game's effectiveness in meeting its defining objective. True flow occurs only when both flows are present, so neither gameplay nor goal-related challenges disrupt the experience.

Bruder et al. (2021) further emphasize that not only do both aspects need to be achieved, but there must also be a valid and integrated relationship between them.

2.2 Self-Determination Theory in Games and Educational Games

Self-Determination Theory (SDT), developed by Deci and Ryan (Ryan et al., 1997), is a widely recognized framework for understanding motivation in both traditional and digital learning environments. In the context of games, SDT posits that intrinsic motivation flourishes when players experience autonomy, competence, and relatedness. These psychological needs are often addressed through game mechanics that allow meaningful choices, provide feedback on progress, and foster social interactions among players.

In educational games, applying SDT principles can enhance engagement and learning outcomes. When learners perceive a sense of autonomy over their actions, feel competent in overcoming challenges, and connect with other participants, they are more likely to persist and achieve deeper understanding. Smirani and Yamani (2024) highlight that effective educational games integrate SDT by designing activities that support these core needs, resulting in increased motivation and better learning retention. Furthermore, research shows that games leveraging SDT principles not only make learning enjoyable but also promote sustained interest and self-directed exploration. (Tyack and Mekler, 2024)

2.3 Player Motivators in Serious Games

Player motivators in serious games are rooted in psychological and behavioral theories that explain why individuals engage with and persist in gameplay. According to Yee (2006) player motivation can be categorized into achievement, social, and immersion, each representing a distinct set of desires such as mastering challenges, connecting with others, and exploring virtual worlds.

Kirchner-Krath et al. (2024) critically examine the theoretical foundations of user-type classifications in the context of gameful design. Drawing on a comprehensive empirical analysis, they investigate the extent to which established user typologies are scientifically grounded and assess their practical relevance for designing tailored game elements. Their results show that assigning individuals to fixed user types is often based on overly simplistic assumptions and lacks sufficient empirical validity. Consequently, the authors argue for a more differentiated understanding of user diversity, emphasizing that such nuance is essential for effectively supporting motivation and engagement in serious games aligning with Yee (2006).

3. The Analyst – An Educational Game for Human Diagnostics

Previous research indicates that it is insufficient to merely incorporate educational content into a game or design it with a specific player profile in mind. It is essential to provide an in-game rationale for players' actions, ensuring that gameplay mechanics are consistent with these objectives. The game should offer diverse motivators to engage as many participants as possible in fulfilling their tasks.

The Analyst aims to support undergraduate students in human science disciplines (sport science, psychology, and education) by bridging theory and practice through a virtual diagnostic environment (Langer et al., 2024). It is based on a two-factor competence model, combining key content areas (e.g., diagnostic methods, quality criteria, and ethics) (Bös, 2017; Ingenkamp and Lissmann, 2008; Schmidt-Atzert et al., 2021) with learning processes such as application and reflection. The game includes three discipline-specific episodes that simulate real professional tasks, alongside quizzes and mini-games to reinforce declarative knowledge. With over 600 questions in varied formats, it offers extensive practice opportunities. Students receive individualized feedback after tasks, including explanations and motivational elements. Additionally, the game is connected to a collaborative platform providing access to relevant literature and learning materials.

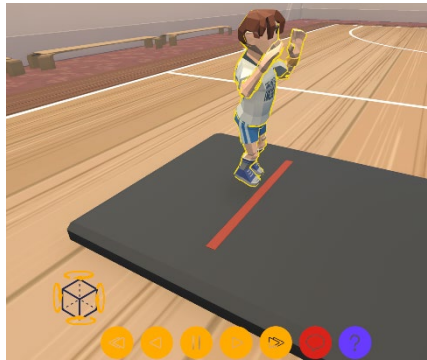


Figure 1: The Player has to identify, if the shown exercise is correct

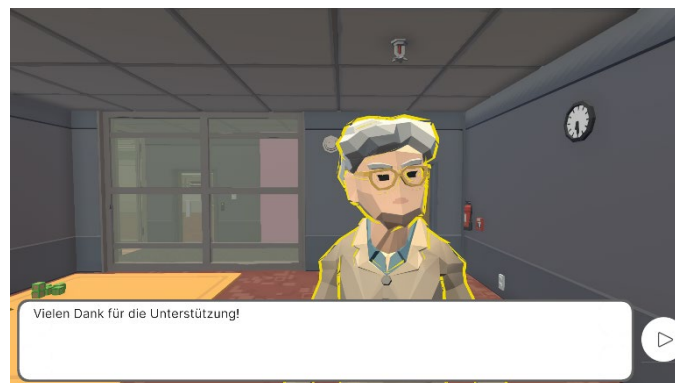


Figure 2: A Character thanks the player after a successful scenario

Participants interact with the game environment as they advance through a range of scenarios designed for both educational value and engaging gameplay. Through participation in various activities, players earn points, which can be utilized to enhance and personalize their office and garden spaces within the game. These incentives encourage progress through episodes featuring predetermined learning scenarios or engagement with interactive elements such as a quiz engine and educational minigames like Hangman using specialized terminology.

4. Methods

This study employed a cross-sectional, exploratory design to evaluate the game TheAnalyst. Quantitative questionnaire data and qualitative feedback were collected after participants played the game.

4.1 Participants

A total of 168 students participated in the study. Participants were recruited through courses in Bachelor's programs in psychology, sport science, and education. The gender distribution was as follows: 110 female, 53 male, 3 diverse or not specified. In terms of field of study, 115 participants were enrolled in psychology, 22 in sport science, 3 in education, and 28 in other disciplines. Regarding age, 14 participants were 19 years or younger, 132 were between 20 and 24 years old, 17 were between 25 and 29 years old, 2 were 35 years or older, and 3 did not report their age. In terms of prior experience, 45 participants had played the game before, whereas 123 had no prior experience. Participants received a grade bonus in their respective course for their participation. Participation was voluntary, and all participants provided informed consent prior to the study. Data were collected anonymously.

4.2 Measures

Participants were asked whether they had previously attended one or more courses related to diagnostics as part of their studies. If applicable, they were also asked to specify which courses they had attended.

Participants reported which game elements they had played (e.g., tutorial, episodes, quizzes, mini-games such as Hangman) and estimated the proportion of time spent on each element (in percentages).

The game experience was assessed using a questionnaire based on a validated instrument developed by Nacke (2009), including positive affect, immersion, flow, competence, challenge, and negative affect. The dimension

“sensory and imaginative immersion” was not included. All items were rated on a 5-point Likert scale ranging from 0 = not at all to 4 = extremely. Participants rated their perceived learning success using multiple items on a 5-point Likert scale (1 = disagree to 5 = completely agree).

4.3 Procedure

The study was conducted in a quiet room at the university (TU Darmstadt). Data collection took place in group sessions with up to 20 participants per session. Each participant completed the study individually using their own laptop. At the beginning of each session, participants were welcomed and received a standardized introduction to the study. They were then instructed to download and install the game.

Participants were given approximately 40 minutes to freely explore the game. They were free to choose which elements to engage with, including the tutorial, episodes, quizzes, or mini-games such as Hangman. No specific gameplay instructions or constraints were imposed. After the gameplay phase, the game session was terminated, and participants completed the questionnaire. At the end of the session, participants received a document containing their tracked in-game parameters, such as completed quizzes, completed episodes, and achieved scores. The total duration of each session was approximately 90 minutes.

5. Results

5.1 Analysis

The collected data were analysed using quantitative methods implemented in Python. A significance level of $\alpha = .05$ was applied for all statistical tests. To assess the practical relevance of the results, effect sizes according to Jacob Cohen (Cohen, 2016) were calculated and interpreted ($d = 0.2$: small, $d = 0.5$: medium, $d = 0.8$: large).

Descriptive statistics included measures of central tendency and dispersion (mean [M], standard deviation [SD], and median). These were calculated for the dimensions of the Game Experience Questionnaire (GEQ), the learning outcome items, and the playtime per game element.

GEQ dimensions were operationalised as the mean of their respective items. Learning outcomes were aggregated across multiple Likert-scale items. Playtime was calculated as the proportional share per game element based on self-reported data and subsequently normalised to ensure comparability across participants. Tutorial playtime was excluded, as it was not completed by all participants.

Assumptions for parametric testing were assessed by examining normality using the Shapiro–Wilk test and visual inspection of histograms. Given the sample size, minor deviations from normality were considered acceptable.

Group differences based on prior diagnostic experience were analysed using Welch’s t-test for independent samples with unequal variances. In cases of substantial violations of normality, results were interpreted with caution and supplemented with non-parametric testing using the Mann–Whitney U test.

Additionally, the free-text responses underwent a qualitative analysis. During an initial phase, using the LLM-supported approach outlined by Arlinghaus et al. (2024), categories were identified inductively. Results from their tool were then reviewed and refined by consolidating categories and reassigning responses as needed.

To analyse the free-form responses, we split any answer that covered more than one topic into separate statements. For example, the response "What I really liked was the variety of tasks and the immediate feedback. I also appreciated that you could revise the episodes right after receiving feedback." was divided into three statements:

- What I really liked was the variety of tasks.
- What I really liked was the immediate feedback.
- I also appreciated that you could revise the episodes right after receiving feedback.

The wording of each statement was preserved, and each was flagged as either positive or negative for later analysis.

As recommended by Arlinghaus et al. (2024), 10 runs of their LLM based program using the openai gpt-4.1-nano model were executed, but it still resulted in redundant categories. In three steps the categories were refined:

1. Each category was reviewed to determine whether it was usable and appropriate for the assigned purpose. If not, the category was deleted and its statements were set aside for later reassignment.

2. Each remaining category was compared to each other category if the categories were distinct. If not, both categories were combined into one. If some statements did not fit anymore, they too were set aside for step three.
3. Using only the remaining, distinct categories the set aside statements were sorted into these categories

This resulted in eight categories filled with statements flagged as positive or negative: Learning Content, Aesthetics, Game Mechanics, Motivation and Fun, Storytelling, Shop System, General Comments, Technical Issues.

5.2 Results

The sample was divided into participants with prior diagnostic experience ($n = 65$) and without prior experience ($n = 103$). Across the entire sample, the Game Experience Questionnaire showed consistently positive ratings across all dimensions, as shown in Figure 1. Participants reported high levels of positive affect ($M = 2.20$, $SD = 0.75$), immersion ($M = 2.17$, $SD = 0.68$), and flow ($M = 1.92$, $SD = 0.83$). Ratings for competence ($M = 1.89$, $SD = 0.73$) and perceived challenge ($M = 1.80$, $SD = 0.68$) were slightly lower but still within a positive range. In contrast, negative affect was low ($M = 0.94$, $SD = 0.67$).

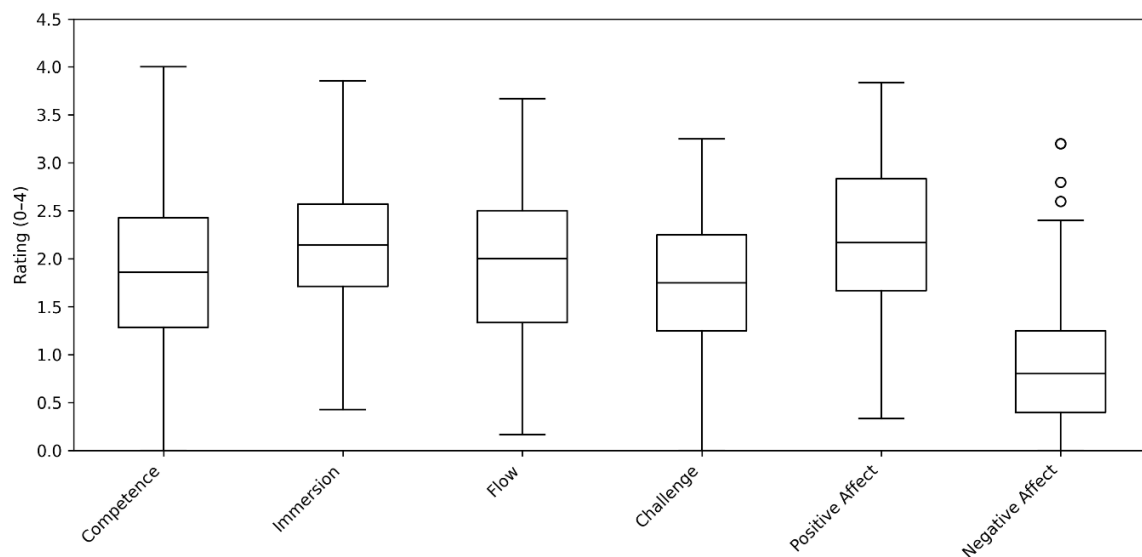


Figure 3: Game experience dimensions

Analysis of playtime distribution revealed that participants spent the majority of their time within the narrative episodes ($M = 74.78\%$, $SD = 22.49$), as well as a smaller proportion engaging with explicitly educational content, such as quiz elements ($M = 7.65\%$, $SD = 12.27$) and the hangman mini-game ($M = 3.69\%$, $SD = 8.89$). However, a considerable portion of time was also spent outside explicitly educational components, with participants spending on average 13.73% ($SD = 13.89$) of their time in free movement (Figure 2). This distribution shows engagement with both educational and non-educational components.

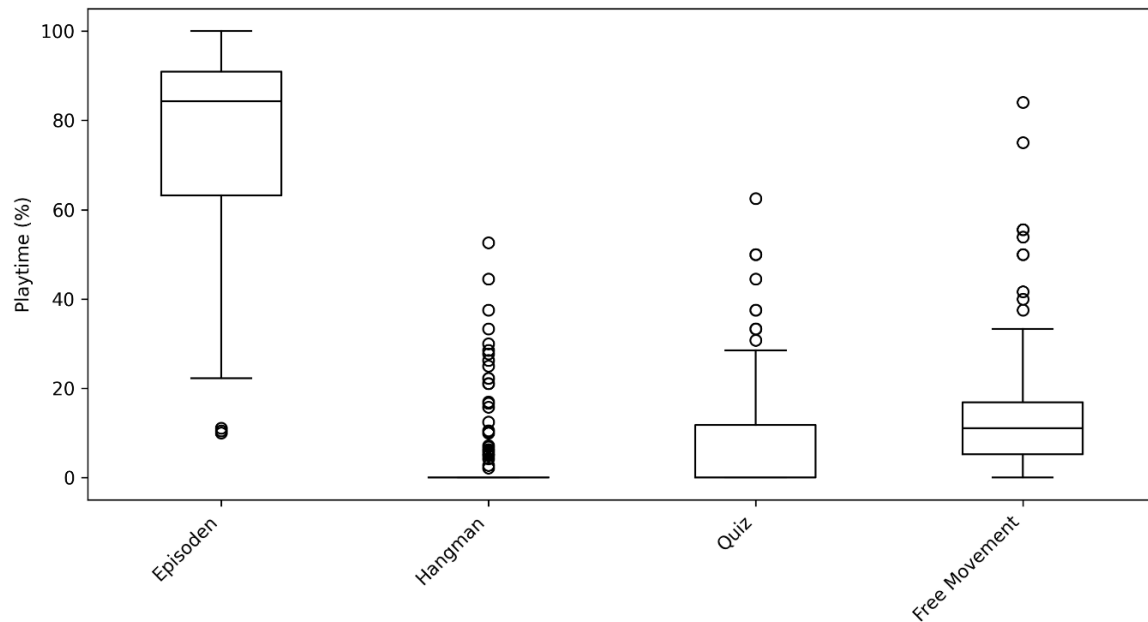


Figure 4: Playtime distribution across game components

With regard to the learning experience, participants reported moderate agreement with learning-related statements, as shown in Figure 3. Active engagement was perceived as particularly beneficial for learning ($M = 3.86$, $SD = 0.97$). Participants also indicated that the game helped them understand the content related to human science diagnostics ($M = 3.40$, $SD = 1.05$) and contributed to an increase in their diagnostic knowledge ($M = 3.31$, $SD = 1.06$). Lower ratings were observed for the perception of having learned new things ($M = 3.04$, $SD = 0.98$) and for overall learning gain ($M = 2.96$, $SD = 0.96$).

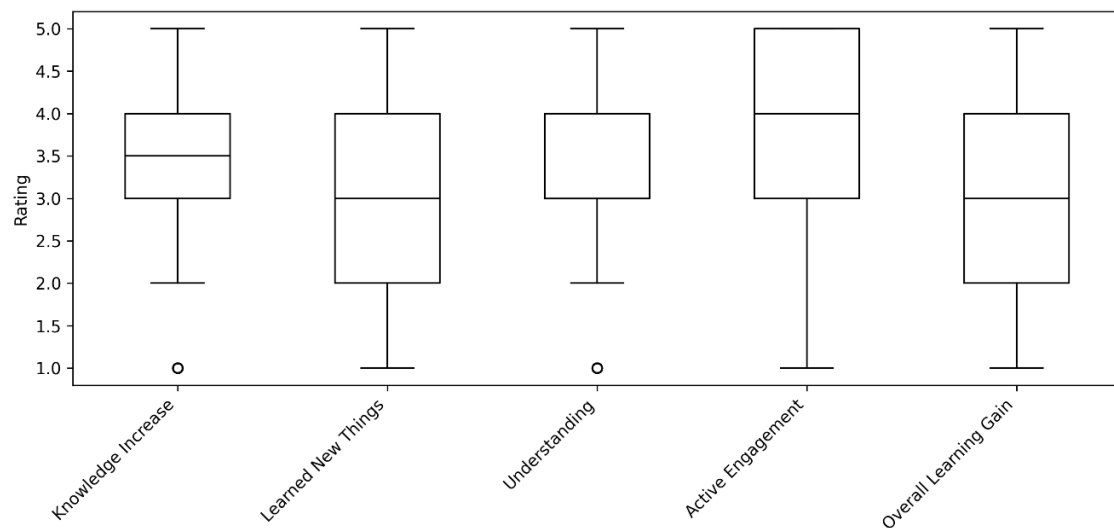


Figure 5: Distribution of learning experience ratings across items

Due to violations of normality, Mann–Whitney U tests were conducted to examine the influence of prior diagnostic experience on perceived learning outcomes. Participants with prior experience reported significantly higher perceived knowledge increase in diagnostics ($U = 4035.50$, $p = .0187$, $d = 0.34$) and better understanding of the learning content ($U = 4000.50$, $p = .0257$, $d = 0.37$). No significant differences were found for perceived general learning ($p = .6519$), support through active engagement ($p = .3820$), or overall learning gain ($p = .1210$), as illustrated in Figure 4.

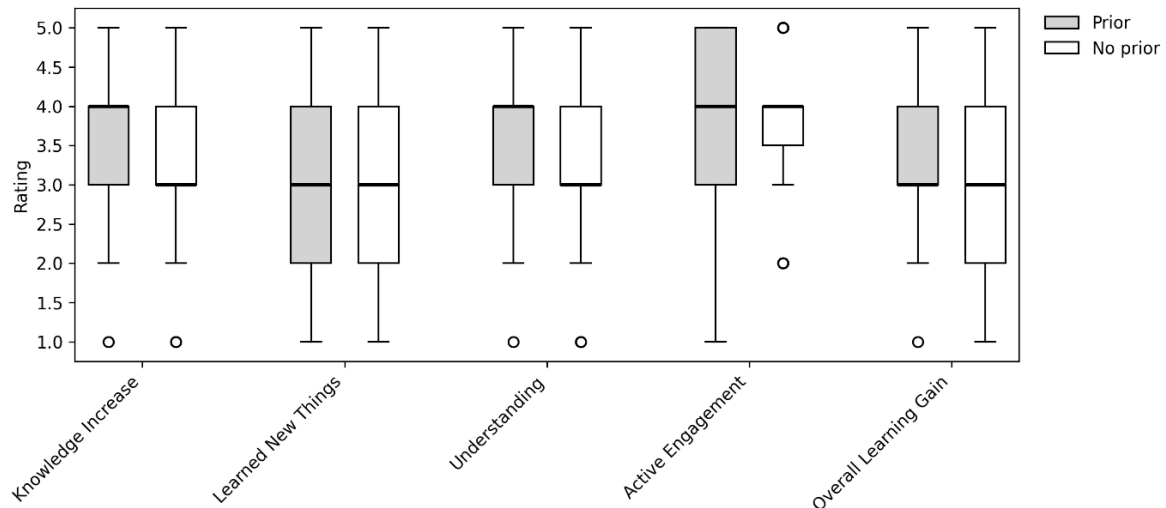


Figure 6: Differences between prior experience groups across learning dimensions

The qualitative analysis included a total of 414 coded statements, of which 241 were positive and 173 negative. Participants frequently described their experience as enjoyable and engaging. Positive feedback was particularly prominent in relation to non-educational aspects of the game. The shop system received exclusively positive feedback. Similarly, game mechanics, motivation and fun, and storytelling were predominantly evaluated positively.

Figure 5 illustrates a more detailed category breakdown, showing that learning content was also evaluated positively overall (66 positive vs. 30 negative statements), although with a lower positive-to-negative ratio compared to gameplay-related features. Game mechanics (49 vs. 8), motivation and fun (24 vs. 6), and storytelling (9 vs. 1) showed high proportions of positive statements. Aesthetics received more mixed feedback (51 vs. 40). General comments were predominantly positive (35 vs. 7). The shop system received only positive feedback (9 vs. 0).

Negative feedback was primarily associated with technical issues, particularly with usability problems and bugs (81 negative vs. 7 positive statements). For example, a substantial number of participants described the controls as clunky and unintuitive at times.

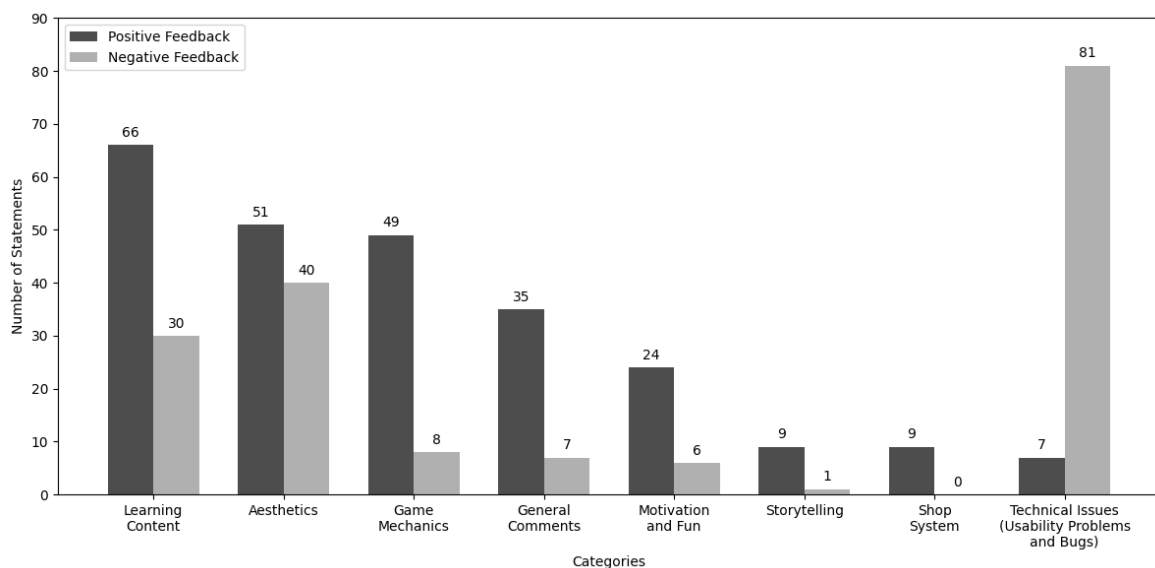


Figure 7: Distribution of positive and negative feedback across categories, sorted by the number of positive statements

6. Discussion

The present study explored user experience, perceived learning, and the influence of prior knowledge in the serious game *TheAnalyst* using a cross-sectional design combining quantitative and qualitative data. Overall, the findings indicate that the game provided a highly positive player experience while supporting moderate but overall positive perceived learning outcomes.

A central finding of the study is the importance of integrating non-educational gameplay elements into educational games. Participants reported positive experiences not only with explicit educational content but also with exploratory and motivational gameplay features. These findings support the assumption that educational games may benefit from balancing learning-related and non-learning-related elements rather than focusing exclusively on instructional content. In line with the Dual Flow model and the “fit” criterion for serious games, the results suggest that meaningful integration between gameplay and educational objectives may contribute to sustained engagement without undermining learning goals.

The consistently positive GEQ ratings further indicate that *TheAnalyst* was perceived as an engaging and immersive learning environment. High ratings for positive effects, immersion, and flow, combined with low negative effects, suggest that the learner-centered design approach successfully supported player engagement. Particularly in exploratory learning environments without predefined progression paths, intrinsic motivation appears to play a central role in maintaining interaction with the learning content.

At the same time, perceived learning outcomes were more moderate than the overall gameplay evaluations. Participants generally agreed that active engagement supported learning and understanding of diagnostic content. However, perceived overall learning gains remained comparatively lower. One possible explanation is the exploratory study design, which allowed participants to freely choose their activities within the game. As a result, exposure to educational content likely varied substantially between individuals.

These findings suggest that serious games such as *TheAnalyst* may be particularly valuable as complementary learning tools that support engagement, contextualization, and application of knowledge rather than as standalone instructional systems.

The findings further indicate that prior diagnostic experience influenced perceived learning outcomes. Participants with prior knowledge reported greater understanding and higher perceived knowledge gains than participants without prior experience. This may suggest that learners with existing conceptual knowledge are better able to contextualize and apply information presented within the game environment. In this regard, the game may particularly support higher-order learning processes related to the application and reinforcement of existing knowledge structures.

The qualitative findings further highlighted the importance of technical stability and intuitive interaction design, as most negative feedback focused on usability problems and technical issues. These limitations may have negatively affected both gameplay experience and perceived learning outcomes but are likely addressable in future development iterations.

Overall, the findings support the relevance of learner-centered serious game design approaches that combine structured educational content with motivational and exploratory gameplay elements. Rather than separating gameplay and learning objectives, the results suggest that educational and non-educational elements can complement each other when meaningfully integrated into the game experience. This supports previous theoretical work emphasizing the importance of balancing engagement and educational purpose in serious game design.

7. Conclusion

This study investigated user experience and perceived learning outcomes in the serious game *TheAnalyst*. The results show that the game provides a highly engaging and immersive experience, with consistently positive evaluations across key dimensions such as affect, immersion, and flow, while negative experiences remained low. At the same time, perceived learning outcomes were moderate but overall positive. However, the findings provide stronger evidence regarding engagement and player experience than regarding actual learning effectiveness, as the evaluation relied primarily on self-reported perceptions rather than objective learning measures.

A central finding is the relevance of a learner-centered and iterative design approach. Continuously aligning game mechanics with learners’ needs appears to have supported a balance between educational content and

engaging gameplay, which was reflected in an experience that participants described as both meaningful and enjoyable.

Furthermore, the results highlight the role of non-educational game elements. Features such as narrative context, reward systems, and interactive mechanics contributed strongly to motivation and engagement. When well-integrated into the game world, these elements can enhance the overall learning experience without compromising educational goals.

Overall, the findings suggest that serious games like *TheAnalyst* can serve as valuable complementary tools in higher education when learning content and gameplay elements are effectively combined. At the same time, further research using objective learning assessments is necessary to better evaluate their actual educational effectiveness.

8. Limitations

This study has several limitations that should be considered when interpreting the results. First, the cross-sectional and exploratory design does not allow for causal conclusions regarding the effects of the game on learning outcomes. Future studies using controlled experimental designs would be necessary to establish causal relationships.

Second, the study relied primarily on subjective measures of learning. While perceived learning provides valuable insights into user experience and engagement, it does not allow firm conclusions regarding actual knowledge acquisition or objective learning effectiveness. Consequently, the findings provide stronger evidence for positive player experience and perceived learning than for measurable learning outcomes and should therefore be interpreted with appropriate caution.

Finally, the game was implemented as a university prototype, which led to several technical limitations. Reported issues such as usability problems and bugs may have negatively affected the user experience and potentially influenced the study results.

9. Future Work

Future work should focus on several aspects to further improve both the system and its evaluation. First, enhancing technical stability and usability is essential, as technical issues such as bugs and unintuitive controls were identified as the main limitations of the current prototype. Addressing these issues is likely to further improve both user experience and perceived learning outcomes.

Second, future studies should incorporate objective measures of learning in addition to self-reported data. While the current study focused on perceived learning, objective assessments would allow for a more comprehensive evaluation of learning effectiveness. A follow-up study is already planned to investigate learning outcomes using objective performance-based measures.

Furthermore, the impact of the game should be examined across different levels of prior knowledge. The current findings suggest that prior experience influences perceived learning, indicating the need for a more differentiated analysis of how learners with varying expertise benefit from the game.

Finally, the game itself should be further developed beyond its current prototype status. This includes refining game mechanics, improving content depth, and exploring adaptive or personalized learning elements to better support individual learning processes.

Acknowledgements

This research has been funded during the Project “The Analyst” funded by “Stiftung Innovation in der Hochschullehre”.

Disclosure of Interests: The authors have no competing interests to declare that are relevant to the content of this article.

Ethics declaration: All applicable ethics committee requirements were complied with; an ethics committee member contributed to the evaluation and is a co-author of this paper. Therefore, no further ethical clearance was needed.

AI Declaration: AI has been used in two cases in the development of this paper:

- As the authors of this paper are not native English speakers, Microsoft Copilot has been used to rephrase chosen sentences for a better understanding
- As stated in Chapter 5, an LLM¹ has been used in the process of inductive categorization of the free form statements of the probands. (Arlinghaus et al., 2024)

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