

Design and Evaluation of a Digital Educational Escape Game for AI Literacy

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Abstract: Developing competencies in the field of artificial intelligence (AI) represents a central task of modern education while preparing young people for an increasingly digitalized world. In this context, practice-oriented, interactive, and motivating learning formats are gaining importance. Educational escape games (EEGs) have already proven to be a promising approach in other educational contexts, as they combine subject-related learning objectives with structured, suspense-based game scenarios and can therefore support both cognitive and affective learning. This paper presents the design and evaluation of the digital EEG “AI Chaos”, which was developed within the framework of a doctoral research project for students in grade 8 and above. The browser-based game was implemented using *Genially*. The didactic design includes three thematically structured game rooms featuring different game mechanics and varied puzzles, as well as a final meta-puzzle. The game aims to convey fundamental concepts and principles of AI learning mechanisms in a comprehensible and motivating way, while fostering media literacy and critical judgment regarding opportunities and challenges related to AI. A quasi-experimental pre-post questionnaire design with supplementary observation protocols was used for the evaluation, in which a total of $n = 181$ students from various types of schools participated. In addition to subject-related knowledge, motivational and emotional aspects such as the experience of flow as well as attitudes toward AI were measured. The results show a significant increase in participants’ knowledge after playing the game. In addition, the learners reported a strong flow experience, with the dimensions of social interaction and perceived competence showing particularly high scores. Attitudes toward AI remained largely stable over the short intervention period. The strongest predictor of cognitive knowledge gain was the participants’ prior knowledge. The activity was rated very positively by the students, who particularly highlighted teamwork, autonomous activity, and the enjoyment of solving puzzles. Overall, the results indicate that (digital) EEGs represent an effective and accessible method for teaching complex future-oriented topics such as AI. Their strengths lie in promoting learning motivation and emotional engagement within the learning process.

Keywords: Educational escape game, Game-based learning, AI literacy, Flow

1. AI Literacy with Game-based Learning?

The perception of artificial intelligence (AI) varies between enthusiasm and skepticism and is strongly shaped by media narratives as well as applications such as ChatGPT (Marr, 2023; Wennker, 2020). At the same time, AI is increasingly becoming part of young people’s lives as reflected in rising usage (Medienpädagogischer Forschungsverbund Südwest (mpfs), 2024, 2025). Therefore, an early engagement with AI is considered essential to foster a reflective approach and to prepare students for societal and professional changes (Kultusministerkonferenz, 2024; Scheiter et al., 2025). In this context, game-based approaches are gaining importance, as they can promote sustainable learning processes through active engagement, experimentation, and experience (Betts, 2013). In the context of innovation topics – such as AI – educational escape games (EEGs) could help make technical relations more comprehensible, foster critical reflection, and raise awareness of relevant issues, as they represent an original method for conveying complex content in a motivating and action-orientated way (Chen et al., 2024; Fotaris and Mastoras, 2019; Kihara et al., 2019; Nicholson and Cable, 2021).

Against this background, this article presents the development, implementation, and evaluation of a digital EEG on artificial intelligence, outlining its theoretical framework, key development decisions, evaluation methods, analytical approach, and the resulting findings and discussion.

2. Theoretical Background

The concept of game-based learning refers to the use of games to support learning processes and extends beyond developing educational games (Becker, 2021; Lampert et al., 2009). Characteristics include the combination of game content with problem-solving challenges and the active engagement of learners, enabling the development of knowledge and competencies within a meaningful context (Qian and Clark, 2016). By this means, escape rooms as a specific game version have come into focus. Originating from interactive entertainment formats, they are now widespread (Corkill, 2009; Nicholson, 2015). They are defined as team-based games in which participants solve puzzles under time pressure to achieve a goal (Nicholson, 2016).

Escape rooms have been adapted for educational purposes since around 2015, to convey learning content in motivating, playful environments, enhance learner engagement, and break down complex tasks into manageable sub-problems (Guigon et al., 2018). These so-called educational escape games are referred to by different terms in literature, but aim to foster knowledge and competencies through collaborative, time-constrained puzzle-solving and are characterized by immersive, action-oriented learning settings (Fotaris and Mastoras, 2022; Sanchez and Plumettaz-Sieber, 2019). They are more strongly embedded in curricula, designed for larger groups, and do not necessarily focus on “escaping” but on understanding content and supporting learning processes. They can be implemented in various formats and differ in terms of immersion, resource requirements, and scalability (Nicholson and Cable, 2021; Sanchez and Plumettaz-Sieber, 2019).

Empirical studies indicate that such games promote motivation, teamwork, and problem-solving skills and can contribute to measurable learning gains. However, they are less suitable for conveying new knowledge and are dependent on design and reflection processes (Veldkamp et al., 2021). Meta-analyses confirm their potential for engagement and collaborative learning, while also highlighting methodological limitations, and the importance of debriefing (Fotaris and Mastoras, 2019; López-Pernas, 2023; Taraldsen et al., 2020).

In the context of (educational) escape games on the topic of artificial intelligence, there is potential to make complex content playfully accessible to diverse target groups and to foster initial levels of understanding and interest (Kihara et al., 2019). Nevertheless, a review of existing educational offerings shows that, while fundamental content is addressed, the didactic quality and depth vary. Therefore, this study develops and implements a game-based format to examine whether EEGs are suitable for fostering AI literacy.

3. Methodological Approach

The target group consists of students from grade 8 onwards, as surveys indicate increasing engagement with AI from this age (mpfs, 2025). The learning content focuses on fundamental concepts such as terminology, functionality, and reflection to promote a differentiated understanding of AI (Bayerisches Staatsministerium für Unterricht und Kultus, 2024).

The game was developed for the School_Lab at the University of Augsburg, an extracurricular STEM-learning environment. There a theme day consists of 75-minute modules and provides hands-on insights into research topics while fostering subject-specific, social, and scientific competencies (University of Augsburg, 2025). Originally, the game was planned as a physical pop-up EEG. However, spatial, organizational, and personnel constraints prevented this.

3.1 Development of the Game

Therefore, a digital EEG was developed allowing for comparable implementation within the given framework, while accounting challenges of digital formats – such as potentially reduced social interaction and learning effects – and addressing them through targeted design elements (Kroski, 2020; Nicholson and Cable, 2021).

3.1.1 Conceptualization of the digital EEG “AI Chaos”

The game development was based on theoretical considerations, didactic requirements, and iterative creation processes. The aim was to create a motivating and educationally effective game through a narrative framework, varied puzzles, and increasing difficulty, connecting to students’ experiences while fostering subject-specific knowledge, problem-solving and reflection skills (Fotaris and Mastoras, 2022; Kiili et al., 2012; Nicholson and Cable, 2021). A point-and-click adventure approach was chosen, as this genre offers a low entry threshold, intuitive usability, clear game mechanics, and collaborative potential (Egenfeldt-Nielsen et al., 2020; Nicholson, 2015). This also led to other design decisions, including an illustrative visual style, intuitive game mechanics, concrete user guidance, the integration of gates, multimedia elements, and a tiered hint system. Considering didactic and technical requirements, the browser-based platform *Genially* was selected, as it largely meets these criteria even without extensive programming skills.

The development process was iterative and lasted several months, guided by established EEGs design principles (e.g. Fotaris and Mastoras, 2022; Nicholson and Cable, 2021). Based on the defined learning objectives and the target group, a realistic, non-dystopian story in a near-future school was created. This setting follows principles of situated learning and is structured as a narrative three-act framework, supported by an in-game ally to provide an guided learning context. The puzzles were aligned with the learning objectives, increasing in complexity, and were structured to promote conceptual understanding and exploratory, problem-solving behavior, as well as flow.

An initial functional prototype was directly implemented digitally and reviewed regarding gameplay flow, clarity, and interactions. Subsequently, a refined prototype was tested with representatives of the target group, resulting in adjustments related to text length, readability, interactive elements, and visual design. Further testing with school classes confirmed the game's functionality and motivational potential. Through these iterative refinements, usability was improved, and game mechanics were structured more clearly.

3.1.2 Brief description of the final game

Although literature recommends linear structures (Fotaris and Mastoras, 2022; Nicholson and Cable, 2021), "AI Chaos" is designed as a hybrid-linear game. Due to its digital implementation, multiple puzzles are integrated within individual rooms that can be solved in parallel, enabling exploration and a stronger sense of control and flow (Jenkins et al., 2009).



Figure 1: Screenshots of the third room of the digital EEG "AI Chaos"

The game begins with an introduction and tutorial conveying the core game mechanics before establishing a central narrative mission – the prevention of data deletion. Players then move through three thematically structured rooms (classroom, school corridor, AI room (Figure 1)), where they acquire and apply key AI concepts through puzzles. These combine interactions, such as quizzes, codes, clozes, and exploratory elements, and are designed to promote knowledge acquisition and application as well as transfer. The final meta-puzzle reviews and deepens the content by combining different task types, thereby increasing engagement with the learning material.

An explicit time limit is intentionally omitted (Nicholson and Cable, 2021). Instead, time pressure is conveyed indirectly through visual and auditory cues, emphasizing content-related learning over speed. A tiered hint system provides support when needed without revealing solutions, encouraging independent problem-solving while avoiding frustration. The game facilitator takes on a supportive role by intervening when necessary and maintaining the game flow. Overall, the game combines narrative, game-mechanical, and didactic elements into a coherent learning environment that covers subject-specific knowledge about AI and promotes competencies such as collaboration and communication.

3.2 Developments of the Evaluation Instruments

To assess the developed game and its effectiveness, an evaluation was conducted. Based on literature, key challenges in evaluating educational (escape) games were considered, particularly small sample sizes, the lack of control groups, and a reliance on subjective self-reports (Fotaris and Mastoras, 2019; Taraldsen et al., 2020). Accordingly, a quasi-experimental pre-post design was chosen, including demographic characteristics, attitudes, knowledge, and player experiences (Fotaris and Mastoras, 2022; Mayer et al., 2014).

Data were collected using standardized online questionnaires with individual, anonymized codes to match datasets. Because AI is linked to innovation and technological progress, the technology readiness was assessed with a shortened version of the *Technology Readiness Index*, covering the dimensions of optimism, innovation, discomfort, and insecurity (Parasuraman, 2000). In addition, gaming affinity had to be rated, as it may influence player experiences and learning outcomes (Mayer et al., 2014). Attitudes toward AI were measured using adapted items from a validated scale, capturing positive and negative attitudes as well as interest in AI

(Schepman and Rodway, 2020). To determine learning outcomes, a knowledge test was developed, covering fundamental concepts as well as application- and reflection-oriented aspects.

Flow experience was identified as a central indicator of game-based learning processes. Accordingly, items were selected based on established scales (e.g. Fu et al., 2009; Sweetser and Wyeth, 2005), including dimensions such as concentration, challenge, control, clear goals, feedback, and immersion. Perceived learning gains, emotional aspects, and social interaction were also included, as these are considered essential components of game-based experiences (e.g. Eppmann et al., 2018; Högberg et al., 2019). To ensure practicality, the number of items was reduced. All scale items were rated on a 5-point Likert scale ranging from strongly disagree to strongly agree.

Overall, the evaluation follows a multidimensional approach covering cognitive, affective, and behavioral aspects. This allows for a differentiated assessment of the effectiveness of the digital EEG, although the reduced set of instruments does not aim to fully capture all theoretical constructs.

3.3 Implementation and Data Analysis

The game “AI Chaos” was integrated into the regular schedule of a program day at the School_Lab. Following random group assignments, participants worked in pairs at prepared PCs. During implementation, the supervising person took on an observational role, logging completion times, occurring difficulties, and support needs. After the game, a joint debriefing session was conducted. This followed EEG literature recommendations and included emotional feedback, gameplay reflection, content-related insights, and transfer (Fotaris and Mastoras, 2022; Nicholson and Cable, 2021).

Observation data showed that the playtime lasted on average 39.8 minutes, while the debriefing took an average of 18.3 minutes, exceeding the recommended ratio of one third gameplay time for debriefing (Nicholson and Cable, 2021). After data cleaning, the sample consisted of 181 students with a mean age of 15.49 years ($SD = 1.56$), with the majority being male (55.80%), followed by female participants (41.44%) and a small proportion identifying as diverse (2.76%). Most participants attended grammar schools (67.40%), while others came from secondary, intermediate, and vocational schools.

The knowledge test was evaluated using a criterion-based scoring system (maximum 14 points). The attitude was measured using eight adapted items and got reduced to a five-item scale after reliability testing. Gaming affinity was operationalized through a single item on general enjoyment of games as well as categorized daily and weekly playtime. To assess flow experience, a composite instrument was used, which resulted in a consistent scale of twelve items after reliability testing. Since the evaluation of the digital game was conducted within the framework of a comparative study, the flow scale was adapted to match the structure of the reference condition to ensure consistency (Thurner-Irmler, 2026). Additional game-specific items related to immersion were excluded from the overall score and analyzed separately. The measurement of technology readiness was excluded from further analysis due to insufficient reliability.

Open-ended feedback regarding the evaluation of the game was also collected and thematically summarized. This analysis was loosely based on qualitative content analysis according to Mayring (2022) and provide further insights into participants’ perceptions. The observation protocols were not systematically analyzed but served to document completion times, identify typical issues, and support ongoing program optimization.

4. Results of the Study

This chapter presents the key findings of the EEG evaluation. The focus is on changes in knowledge and attitudes toward AI, the experience of flow, as well as relationships and influencing factors. Demographic differences and qualitative feedback from participants are also considered.

4.1 Changes in Knowledge and Attitudes Toward AI

In the knowledge test, students achieved an average score of 4.91 points ($SD = 2.34$) prior to the intervention and 7.94 points ($SD = 2.84$) afterward, corresponding to a mean increase of 3.03 points. As the distributions deviated from normality, the Wilcoxon signed-rank test was used for the pre-post comparison. This revealed a significant increase in knowledge between the pretest ($Mdn = 5.0$) and posttest ($Mdn = 8.0$), $T = 13,975.50$, $p < 0.001$, $r = 0.745$. Thus, knowledge improved substantially after the intervention.

In contrast, no significant differences in attitudes toward AI were found. Mean values were $M = 3.91$ ($SD = 0.57$) before the intervention and $M = 3.94$ ($SD = 0.72$) afterward. The Wilcoxon signed-rank test

indicated no significant difference between pre- and post-survey, $T = 5,180.50$, $p = 0.140$, $r = 0.11$. Overall, participants' attitudes toward AI remained stable.

4.2 Flow Experience

Flow experience was assessed exclusively in the post-survey. For the overall construct, the game group showed a mean value of $M = 4.03$ ($SD = 0.47$), indicating a positive gameplay experience. The highest ratings were observed for the items "We worked well together as a team" ($M = 4.32$, $SD = 0.90$), "I felt that I could accomplish the tasks" ($M = 4.28$, $SD = 0.69$), "I had fun" ($M = 4.23$, $SD = 0.67$), and "I am satisfied with the game" ($M = 4.22$, $SD = 0.69$). Perceived learning about AI was also rated positively ($M = 4.18$, $SD = 0.73$).

The additional items on immersion provide a differentiated picture: the statement "The story captivated me" was rated neutrally ($M = 3.16$, $SD = 0.94$). Similarly, the item "I felt more like I was learning than playing" showed slight disagreement ($M = 2.62$, $SD = 0.97$). Potential distraction caused by game mechanics was rated neutrally ($M = 3.33$, $SD = 1.08$). Overall, the results suggest that the game was experienced positively in terms of teamwork, perceived achievability, and enjoyment, while narrative engagement was lower.

4.3 Relationships Between the Constructs

Due to non-normality, Spearman's rank correlation coefficient was used to analyze the relationships between variables. A moderate, significant correlation was found between prior and post knowledge ($r = 0.459$, $p < 0.001$). Weak correlations were also observed between prior knowledge and flow experience ($r = 0.192$, $p = 0.010$), as well as between post knowledge and flow ($r = 0.200$, $p = 0.006$). Attitudes toward AI were stable, with a strong correlation between pre- and post-measurement ($r = 0.597$, $p < 0.001$). Gaming affinity showed no significant relationships with the examined constructs, suggesting that the gameplay experience did not substantially depend on whether participants generally considered themselves interested in gaming.

4.4 Predictors of Knowledge, Attitudes, and Flow

To examine predictors, multiple linear regression analyses were conducted. For posttest knowledge, a significant model emerged ($F(3, 177) = 16.547$, $p < 0.001$, $R^2 = 0.219$), with prior knowledge as the only significant predictor ($\beta = 0.403$, $p < 0.001$). Attitudes toward AI after the intervention ($F(3, 177) = 37.881$, $p < 0.001$, $R^2 = 0.391$) were significantly predicted solely by prior attitudes ($\beta = 0.618$, $p < 0.001$). For flow experience, a weaker but significant model was found ($F(3, 177) = 3.586$, $p = 0.015$, $R^2 = 0.057$), in which prior knowledge again served as the only significant predictor ($\beta = 0.170$, $p = 0.022$). Neither gaming affinity nor prior attitudes toward AI contributed significantly to the prediction. Overall, the findings indicate that prior knowledge plays a central role in learning outcomes and gameplay experiences, whereas other factors are less influential.

4.5 Influence of Demographic Variables

No significant relationships were found between age and gaming affinity, knowledge, attitudes toward AI, or flow experience. No gender differences emerged in knowledge, attitudes, or flow experience. Only gaming affinity was significantly higher among male participants, without affecting other variables.

Regarding school types, the Kruskal-Wallis test revealed significant differences in post knowledge ($H(3) = 20.341$, $p < 0.001$). Vocational school students achieved the highest scores in both the pretest ($M = 6.23$, $SD = 2.13$) and the posttest ($M = 10.62$, $SD = 1.39$) and showed the greatest gains. Students from intermediate and grammar schools were in the mid-range, while students from lower secondary schools received the lowest scores, although they also improved.

4.6 Open Feedback

The overall evaluation of the game was positive ($M = 4.24$, $SD = 0.70$): 37.02% of participants fully agreed with the statement "Overall, I liked the activity," and a further 51.93% somewhat agreed. In open-ended responses, participants highlighted the game itself, the puzzles, the playful concept, and their autonomy in solving tasks. The perceived knowledge gain, the combination of fun and learning, and the opportunity for independent discovery were also emphasized. Critical feedback concerned the amount of text and information density, which were sometimes called described as too extensive or demanding.

5. Discussion

The results show that the digital EEG "AI Chaos" led to a significant increase in knowledge and can therefore be considered an effective format for teaching fundamental AI concepts. A clear strength lies in the flow

experience: the construct received high ratings, particularly in the dimensions of social interaction, perceived competence, clear goal structure, and positive emotions. The importance of a balanced relationship between challenge and skills as a foundation for flow is also confirmed (Kiili et al., 2012). The game is therefore well suited for use in motivational learning phases and for fostering engagement, which remained high despite only moderate narrative involvement (Cruaud, 2024). Despite the positive gameplay experience, no significant change in attitudes toward AI was observed. This suggests that attitudes should be regarded as relatively stable constructs that are difficult to change through short-term interventions (Mayer et al., 2014).

Prior knowledge was the strongest predictor of learning outcomes and emerged as a factor influencing flow experience. This shows that without a cognitive foundation, even playful approaches have limited effectiveness. Gaming affinity and age had no significant effects, indicating suitability for learners even with low gaming affinity and across different age groups (Nicholson, 2016).

The game was evaluated very positively overall, with emphasis on active engagement, puzzle mechanics, and the playful learning approach. However, a central tension emerged: even with a game-based implementation, the amount of text was perceived as challenging. This highlights the importance of linguistic design and cognitive load, particularly regarding the declining reading proficiency (OECD, 2023).

Despite its sample size, the study of the digital EEG “AI Chaos” has limitations. Due to the quasi-experimental design without full randomization, group composition effects and socially desirable responses cannot be ruled out (Döring, 2023). In addition, the implementation and facilitation were conducted by the same person, which may have introduced bias (Pentzek et al., 2010). Further limitations arise from the use of reduced, partially validated instruments and the focus on short-term effects (Döring, 2023). Overall, the study should therefore be considered exploratory and limited in generalizability.

6. Conclusion

The findings show that the digital EEG “AI Chaos” can provide an effective approach to complex topics such as AI. The evaluation further confirms a significant increase in knowledge. At the same time, it becomes evident that the particular strength of game-based learning formats lies less in cognitive outcomes and more in promoting motivational and social aspects. Flow experience, perceived competence, collaboration, and active problem-solving processes play a key role in shaping learning as a social and emotional process. The results indicate that digital EEGs are especially effective where learning extends beyond knowledge acquisition and is an active, experience-based action.

However, it must be noted that cognitive learning outcomes strongly depend on prior knowledge. The results also indicate that short-term interventions have little impact on stable constructs such as attitudes toward AI. Feedback regarding the amount of text and the heterogeneous perception of task difficulty further highlight the importance of adaptive, target group-appropriate design.

The digital EEG should not be regarded as a superior learning format, but rather as a didactically meaningful complement. Its value lies in the activation, consolidation, and application of knowledge, as well as in fostering motivation and teamwork. For practice, this requires the need for a deliberate and context-sensitive use: learning success depends not on the game itself, but on the quality of its didactic integration and the subsequent debriefing. In this respect, “AI Chaos” serves as an example of how digital game-based learning can be effectively integrated into educational settings – while considering its potential and design-related challenges.

Ethics and AI Declarations: This study involved human participants using standardized questionnaires. All procedures complied with applicable data protection regulations, and the instruments were reviewed and approved by the data protection team of the University of Augsburg. AI-based tools were used in a limited capacity for language support, specifically for translation purposes of this article.

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