Lehren und Lernen mit Intelligenten Systemen

Bachelorarbeit

Gender Differences in the Impact of Gamification Elements on Performance and Anxiety

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Abstract

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Keywords: Gamification, Gender

Gender Differences in the Impact of Gamification Elements on Performance and Anxiety

Gamification, especially in the context of education is nothing new and has been used by societies long before the modern era. The concept of grading can be seen as a form of gamification, as it adds feedback and a competitive element to the learning process. But in recent years especially with the advance of computers, gamification has become an increasingly popular topic in education science (Swacha, 2021). Especially in computer science the use of gamified elements is well researched (Dichev & Dicheva, 2017), which could be related to the already great use of computers in the field. But as this field is still relatively new, many topics are still not well researched, especially how individual factors, such as gender, can influence the effects of gamification (Dehghanzadeh et al., 2024; Oliveira et al., 2023). This thesis aims to explore the effects of different gamified elements and their combinations on performance and anxiety in a digital learning environment, especially focusing on the influence of gender on these effects. Digital learning environments, or tutoring systems, were hugely affected by the shift of teaching to remote classes during the COVID-19 pandemic. In 2019, 54% of students utilized digital learning materials, which increased to 70% the following year. Meanwhile, only 32% of German scholars aged ten to fifteen engaged with digital learning materials, a figure that doubled to 64% just one year later. Gamification and Digital learning environments are often combined (González et al., 2014) with good results (Jackson & McNamara, 2013) regarding motivation and enjoyment. Implementing gamified elements into tutoring systems, while showing positive impact overall, could also lead to negative outcome, for example demotivation while being part of a leaderboard (Almeida et al., 2021). Almeida et al. (2021) also found in their systematic mapping, 77 papers mentioned negative effects like cheating, lack of understanding and most often lack of effect. This leads to the question on how gamified digital learning environments could be further improved.

Multiple meta analyses came to the conclusion, further investigation on the effects of different gamification elements on individuals is needed Dehghanzadeh et al. (2024), Hamari et al. (2014), and Oliveira et al. (2023), as future systems could also use more individualized data to further enhance the experience of the gamified elements inside the tutoring system. Factors mentioned by Dehghanzadeh et al. (2024) include gender and age, Oliveira et al. (2023) mentions culture and gender. All studies highlight the importance of the context, in which the learner is exposed to gamified elements.

Gender could be one of the most significant factors, as it is often discussed in aforementioned studies and was already subject to many studies concerning gamification in different groups and systems. Albuquerque et al. (2017) which serves as foundation for this paper, investigates the influence of stereotype threat in gendered gamified educational scenarios. Dehghanzadeh et al. (2024) showed, that gender is the most controlled factor in their reviewed articles, with mixed outcome. Some studies showed no effect of including gender, others significant differences.

It becomes crucial to expand our understanding of how gender influences the effectiveness of various gamified elements in digital environments. This thesis will assess whether these factors can enhance the learning experience without disadvantaging any gender group. Thus, the primary goal is to design digital tutoring systems that fully leverage the potential of gamification to benefit all users equally, fostering an inclusive and effective educational environment.

Theoretical Background

Tutorial systems

Tutorial systems have become increasingly popular in educational settings, offering a wide range of features and flexibility to support students learning processes. These systems can range from simple instructive texts to simulations and virtual realities, serving as models that simplify aspects of the real world to reduce complexity mostly from interconnection and context of knowledge for both the machine and the user (Psotka et al., 1988). Those Environments are in use at higher education institutions and since the COVID-19 pandemic, they have become more important (El Hadbi et al., 2024) and widely researched, especially in the field of computer science (Zawacki-Richter et al., 2019).

Tutorial systems are often enhanced with some sort of intelligence (ITS). A dynamic adaptation to learner's needs, incorporating usage factors such as performance, but also external factors such as age, culture or gender (González et al., 2014; Nkambou et al., 2010). The role of Artificial Intelligence in this process could also become more important in the future, as it could have a significant, yet unknown impact on ITS (Zawacki-Richter et al., 2019).

Tutoring Systems are often used in combination with gamified elements, significantly improving the learning experience (Dermeval et al., 2019). Jackson and McNamara (2013) found that the use of gamified elements in tutoring systems significantly improved the motivation and performance of students compared to traditional tutoring systems which lead to boredom and disengagement after long periods of use.

Incorporating gamified elements not only enhances the engagement and motivation within the ITS but also necessitates mechanisms for tracking progress, such as content unlocking (González et al., 2014). The evolving landscape of ITS research also includes emotional and relational dynamics, linking student emotions and teacher-student relationships to learning efficacy and motivation (Woolf et al., 2010). These insights have led to the development of digital companions, often named pedagogical agents, within ITS that significantly boost the learning potential and self-concept of students, particularly those who are low-achieving. Intriguingly, a study noted that ITS programs with a male companion were muted twice as often as those with a female companion, highlighting potential gender differences that could be explored to enhance the predictive capabilities of the student model (Woolf et al., 2010).

Gender

Gender, as a concept within social sciences, refers to more than the binary categorization of male and female. It encompasses a range of identities and experiences that are shaped by a complex interplay of biological, psychological, and social factors. Gender is not solely determined by biological characteristics; instead, it is increasingly recognized as a spectrum, acknowledging the presence of diverse gender identities beyond the traditional binary understanding (Lindqvist et al., 2021). Socialization plays a critical role in shaping gender identity. It influences how individuals perceive themselves and interact with their surroundings based on the gender norms prevalent within their society. These norms dictate behaviours, roles, and expectations, which are often internalized from an early age through various socialization agents like family, media, educational institutions, and peer groups (Kampshoff & Wiepcke, 2012). While acknowledging the spectrum of gender identities, this thesis will focus primarily on the binary categorization of gender—male and female. This approach does not negate the validity of non-binary or genderqueer identities but rather limits the scope of investigation to traditional gender roles within the binary framework.

Gender is a critical variable to consider when deploying tutorial systems due to its significant influence on learning preferences and outcomes. Research indicates that male and female students exhibit distinct preferences for learning modalities and react differently to adaptive learning technologies. For instance, studies have shown that while male students often prefer multimodal instructional approaches, female students tend to favor single-mode learning, particularly kinesthetic styles (Wehrwein et al., 2007). Additionally, the use of adaptive learning technologies has demonstrated a more pronounced improvement in performance among male students compared to their female counterparts in subjects like Mathematics and Portuguese (De Santana et al., 2016). Moreover, technological proficiency and communication challenges in online settings have been identified as factors affecting learning satisfaction, with older students showing a stronger preference for face-to-face learning, which may be due to less familiarity with digital technologies (Dabaj, 2009). Recognizing and addressing gender differences in learning styles and preferences is essential for tailoring educational technologies and strategies, thereby optimizing tutorial systems to enhance learning efficacy and engagement for all students.

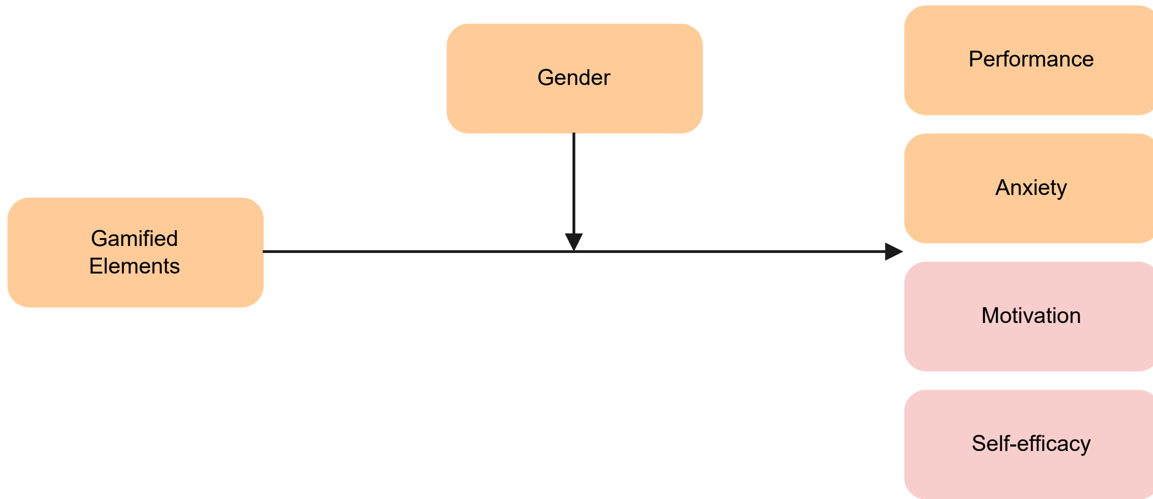
The design of virtual classroom environments significantly influences gender disparities in computer science courses, impacting both course selection and anticipated success. Research by Cheryan et al. (2011) shows that altering the design of virtual classrooms from stereotypical computer science environments to more neutral or non-stereotypical settings (e.g., featuring art, nature posters) can substantially increase women's interest and perceived success in computer science. This change in environment reduces the gender gap by fostering a greater sense of belonging among female students, which is not as pronounced in male students.

Gamification

Gamification can be defined as "the idea of using game design elements in non-game contexts" (Deterding et al., 2011) to further increase motivation and user activity within interaction design (Deterding et al., 2011). These game-design elements, subsequently called gamified elements, are elements often found in classical video games. However, the concept of gamification is different from designing a game, the focus lies on using the addictive component (González et al., 2014). Often used elements are points, badges, leaderboards and avatars, other mechanisms include content unlocking, storytelling and memes (Zainuddin et al., 2020). Often those elements are used specific constellations like the PBL triad described by Werbach and Hunter (2012), which contains points, badges and leaderboards. A system that is not only known from games, but also everyday enterprise features like loyalty programs and employee competitions (Werbach & Hunter, 2012). Points because they add an absolute scale, badges because they represent a status symbol and work like a temporary goal to strive toward and leaderboards to compare yourself to peers (Werbach & Hunter, 2012). One of the positive effects of gamification is brought by the feedback in different forms (task, process, self-regulation, self) either immediate or delayed. Feedback is one of the most important factors in the relation between education and learning Sailer and Homner (2020). The use of gamified elements showed positive outcomes in multiple studies, in general (Hamari et al., 2014) as well as in education specific contexts (Sailer & Homner, 2020). But gamification, especially some elements like leaderboards, can also lead to negative outcomes. Leaderboards, while motivating through comparison, have been reported to demotivate participants (Almeida et al., 2021). "Pavlovication" as Klabbers (2018) calls it, Gamification, as it is often a short question-answer-reward-cycle, conditions the user to learn conditional and narrows the possible ways to solve a problem down (Klabbers, 2018). Some studies also suggested that gamified learning platforms also lack individualism regarding choice and display of gamification elements, resulting in discomfort and negative emotions (Santos et al., 2023). To combat this missing individualism, Dehghanzadeh et al. (2024) and Oliveira et al. (2023) suggest using more independent variables to taylor the use of gamification elements.

Hypotheses

As noted in the first chapter, there are open questions regarding the efficiency of various gamified elements and how different genders relate to these gamified elements. The question of the efficiency of certain elements and combinations of elements remains unresolved (Dehghanzadeh et al., 2024). To explore the connection between gender and gamification elements, we have created the following model:



This model additionally incorporates concepts of motivation and self-efficacy, which, although not featured in my thesis, are included in the doctoral thesis of **Nadine Koch**.

Since males perform better than females in solving progressive matrices from age 15 onward, Hypothesis **H1a** one-sidedly formulated (**ravenStandardProgressiveMatrices2003**). The hypotheses we want to investigate in this work are:

H1 Males and females differ in their cognitive and affective states.

a) Male performance is better compared to female.
b) Male and female students differ regarding their anxiety levels.
c) Male and female students differ regarding their motivation.
d) Males have a higher self-efficacy compared to females.

H2 Different gamified elements have a varying impact on the cognitive and affective states.

a) Gamified elements impact performance differently.
b) Different gamified elements impact anxiety levels differently.
c) Different gamified elements impact motivation differently.

d) Different gamified elements impact self-efficacy differently.

H3 Different gamified elements differently impact the cognitive and affective states of males and females.

a) The influence of different gamified elements on performance differs between males and females.

b) The influence of different gamified elements on anxiety levels differs between males and females.

c) The influence of different gamified elements on motivation differs between males and females.

d) The influence of different gamification elements on self-efficacy differs between males and females.

All hypothesized effects result from interacting with the gamified digital learning environment.

Methods

Participants

119 participants were recruited from the university campus, with 69.74% identifying as 'male', 28.57% as 'female' and 1.68% as 'other'. Participants were aged between 18 and 27, the average age was 22 years, with a standard deviation of 2.4 years. The study programs most frequently represented were computer science, software engineering and aerospace engineering. Participants each received €15 as monetary compensation for their involvement in the study.

Design

This study explored the impact of various gamified elements and participant gender on performance and anxiety. The study design was two factorial with the factors gamified elements and gender. The first factor and independent variable was gamified elements, with participants randomly assigned to one of eight conditions: Avatars (A), Badges (B), Points (P), Leaderboards (L), Narrated Content (N), combinations of Points, Badges, Leaderboards, and Avatars (PBLA), Points, Badges, Leaderboards, Avatars, and Narrated Content (PBLAN), and no gamified elements. The other factor gender was measured in male, female and other. Each participant experienced three distinct conditions, which were sent by the server out of a randomized pregenerated batch, ensuring that all conditions were evenly distributed across participants. Participants underwent a series of tests in a fixed order during each round, beginning with a gamified performance test in a digital learning environment followed by non-gamified assessments for anxiety, self-efficacy, and motivation. At the end participants were given a monetary compensation of €15. The performance tests utilized standard progressive matrices, adapted with gamification techniques to engage and challenge participants uniquely in each round. The dependent variables included:

- **Performance**, assessed through accuracy and response times in the gamified progressive matrices.
- **Anxiety**, evaluated using a standardized questionnaire immediately after the performance test. Anxiety was measured using a shortened form of the State-Trait Anxiety Inventory (STAI) with 6 items (Marteau & Bekker, 1992).

This research employed a repeated-measures design, where each participant was exposed to three different gamification conditions chosen randomly. This within-subjects approach facilitated the analysis of individual responses to each condition across the different rounds, providing insights into how variations in gamification can affect psychological states and performance.

Materials

Physical environment

The study was conducted in two separate rooms in the cellar of a university building, one equipped with five and one with seven iMacs. As Christy and Fox (2014) suggested that the physical environment can influence the results, both rooms were equipped with the same furniture and lighting and were furnished very dry, like a typical software laboratory.

Virtual environment

The software used in this study was built by the author using SvelteKit in frontend and KTor in backend. Its UI was designed after the study by Albuquerque et al. (2017). On the iMacs the study was displayed full-screen mode using the Safari web browser to ensure no further distractions. The study consisted of 4 screens. A consent screen gave an overview and explained the data collection to the user. The consent screen had to be accepted in order to proceed. A personal detail screen collected said data; gender, age and study program. Participants also had to enter a deletion code in order to request their data's deletion after the collection.

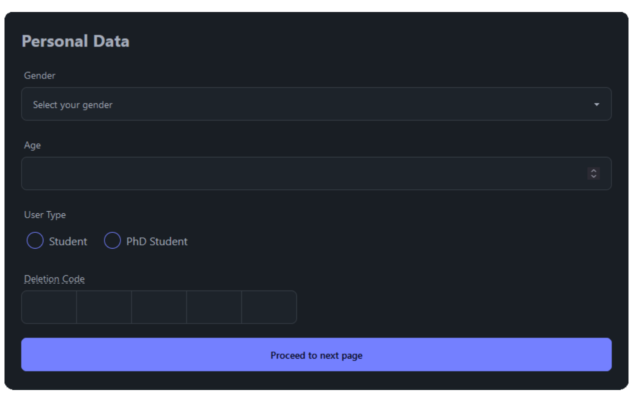


Figure 1

The personal details collection form

The next screen was the gamified learning environment, where the participants had to solve 20 questions in a row while being exposed to the gamified elements. The matrices were taken from Albuquerque et al. (2017), to generate 60 questions out of the 20, the 40 questions for iteration two and three were slightly altered versions of the original 20 made by this author.

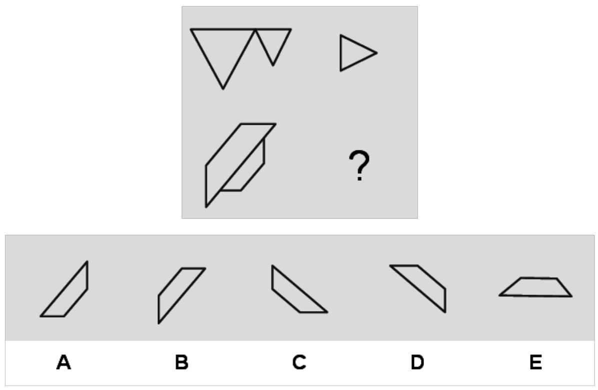


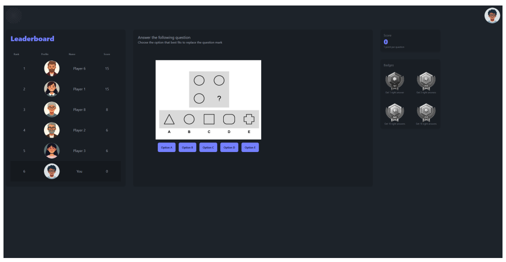
Figure 2

A standard progressive matrix, one of the tasks given to the participants

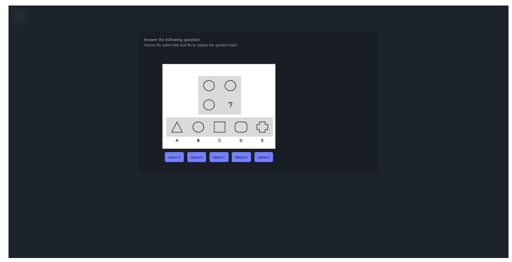
The gamified learning environment consisted of different UI elements representing the gamified elements.

- **Leaderboards**: A list of participants and scores, including the current participant. The other players shown were not real.
- **Badges**: An array of four badges that were awarded for 1, 5, 10 and 18 correctly answered questions.
- **Avatars**: A small avatar that was shown in the top right corner of the screen and on the leaderboard. To increase identification with the avatar further, the participants were asked to choose one of 15 different avatars before the iteration.
- **Narrated content**: Narrated content was shown in the bottom right corner of the screen. It was presented as a speech bubble with an avatar next to it, in case avatars were enabled. It showed a random praise or encouragement sentence every three questions.

- **Points**: A counter next to the question frame showed the current points. One point was awarded for each correctly answered question.



(a) *The Digital Learning Environment with Points, Badges, Leaderboards and Avatars enabled. Narrated content in only shown between questions.*



(b) *The Digital Learning Environment with no Gamified Elements enabled*

Figure 3

Comparison of the Digital Learning Environment with and without gamified elements enabled

After the gamified learning environment, the participants were shown a questionnaire for anxiety, motivation and self-efficacy. The three questionnaires were a six-question shortened form of the State-Trait Anxiety Inventory (STAI) (Marteau & Bekker, 1992), the eight-question General Self-Efficacy Scale (GSE) (Guay et al., 2000) and the 16-question Situational Intrinsic Motivation Scale (SIMS) (Chen et al., 2001).

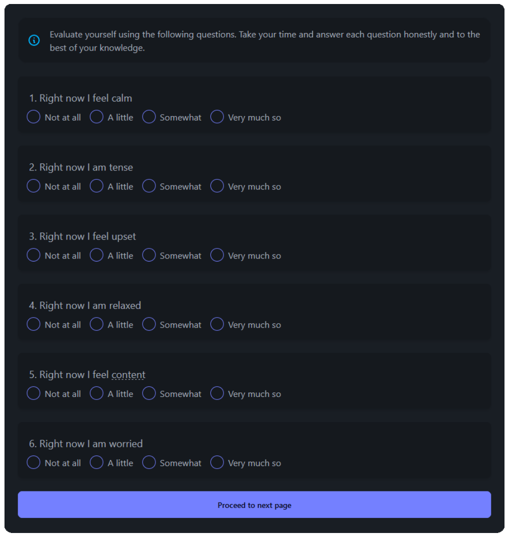
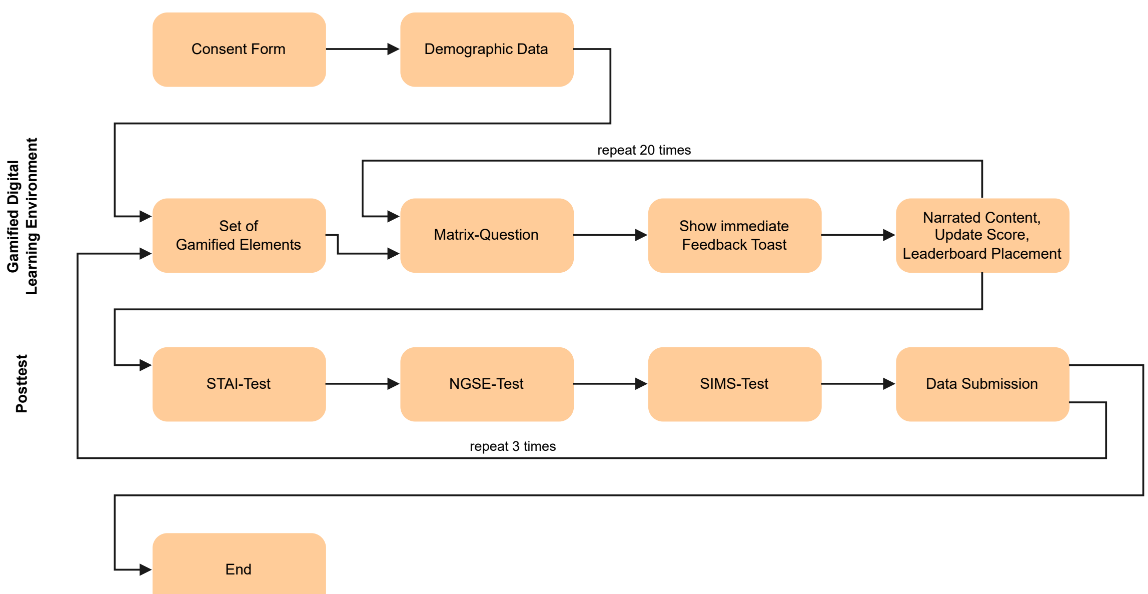


Figure 4

The anxiety questionnaire

To submit data to the backend there was a data submission screen that guided the participants to the next iteration or in case of the third iteration to the end of the study.

Procedure



Participants have been enlisted at the university campus and invited to engage in a study concerning gamification, with an incentive of 15€ offered upfront for their involvement. Following a brief overview of the study's framework, they have been directed to select both a room and a computer. The initial screens presented were those seeking consent and outlining the study details. Subsequently, participants have inputted their data, leading into a series of three questioning phases. Each phase has initiated with the gamified learning environment, followed by three questionnaires, and concluded with a data submission interface. After answering one question the next question has a one-second delay which increases to four seconds if narrated content is shown. The sequence and consistency of the testing procedure, including the series of questions asked in the gamified digital learning environment have always been maintained to ensure the reliability of measurements and comparability of results across the various stages of the experiment. Participants have been advised to proceed at their own pace and refrain from communicating with fellow participants throughout the duration of the study. Upon completion of the third iteration, they have been acknowledged for their contribution and compensated with the 15€.

Scoring

The data was cleaned and processed before analysis to ensure accuracy and reliability. The scores for the different conditions were calculated as follows:

- **Performance:** Performance was calculated as the ratio of correctly answered questions to the total number of questions. If this ratio was below 0.25 for any dataset, that dataset was excluded from further analysis. This threshold ensures that only participants with a sufficient level of engagement are included in the study.
- **State-Trait Anxiety Inventory (STAI):** The STAI scores were calculated using the six-item short-form version of the State scale, as developed by Marteau and Bekker (1992). Participants rated their responses on a scale from "Not at all" to "Very much so,"

corresponding to numerical values from zero to five. The original test contains both anxiety-present and anxiety-absent items, with appropriate weights applied as per the guidelines by Marteau and Bekker (1992). Negative weights were used for items indicating anxiety (e.g., "Right now I am worried").

- **New General Self-Efficacy Scale (NGSE):** The NGSE scores were calculated based on the method outlined by Chen et al. (2001). Participants' responses were averaged to obtain the mean score, which indicates their overall self-efficacy across different situations. This scale, validated by Chen et al. (2001), captures the general sense of self-efficacy.
- **Situational Motivation Scale (SIMS):** The SIMS was used to measure participants' situational motivation in the gamified test environment. This scale assesses intrinsic motivation, identified regulation, external regulation, and amotivation, providing a comprehensive view of the participants' motivational states. Scores were calculated by averaging the participants' responses, as suggested by Guay et al. (2000).

Evaluation

Data Exclusion

Participants who identified their gender as "other" were excluded from the analysis because the present research available and used for this thesis primarily focuses on comparisons between male and female participants. This criterion led to the exclusion of two participants. Additionally, participants who achieved less than 25% correct answers in the gamified learning environment were excluded. This threshold was set because there were five possible answers for each question, and random clicking would statistically result in a 20% correct response rate. Therefore, a performance below 25% suggests either random guessing or a fundamental misunderstanding of the task. Furthermore, any incomplete data sets were excluded to ensure the integrity and consistency of the analysis, resulting in the exclusion of one additional participant.

Initially, there were 120 data sets, and after applying the exclusion criteria, 117 data sets remained.

Outline of statistical analysis

Having preprocessed and cleaned the data, we proceeded with our statistical analysis using linear mixed models (LMMs). These models were chosen for their ability to handle the complexities of repeated measures from the same subjects under varying conditions. By incorporating both fixed effects (gender and gamified elements) and random effects (individual differences), LMMs provided a robust framework for our analysis.

We utilized the Nelder-Mead optimization method to estimate the parameters of our models. This method is ideal for our needs as it efficiently handles models with multiple interacting effects without requiring derivative calculations, making it suitable for our complex dataset.

For the estimation of variance components within our models, we employed Restricted Maximum Likelihood (REML). REML is preferred in mixed model contexts because it adjusts the estimates for the fixed effects, providing unbiased variance estimates despite the presence of random effects.

Finally, to ensure accurate inference regarding the fixed effects, we applied the Satterthwaite approximation for estimating degrees of freedom. This method helps in achieving more reliable p-values by adjusting the degrees of freedom for the complexity of the model, crucial in cases with multiple levels of interactions and a limited sample size.

This combination of methods and their implementation through LMMs allowed us to systematically analyse the effects of gender and gamified elements on performance and anxiety, controlling for individual variability and the specifics of the experimental design.

Results

Table 1

Ergebnisse des Experiments

Variable	Mean experimental	Mean control	Estimated difference d	t	p	df	95% LCI of d	95% UCI of d	Cohen's d
gender [male]			0.01	0.27	0.994	277.62	-0.06	0.08	0.07
gamifiedElement [Points (P)]			-0.04	-1.35	0.493	211.82	-0.11	0.02	-0.33
gamifiedElement [Badges (B)]			0.01	0.21	0.994	214.27	-0.06	0.08	0.06
gamifiedElement [Level (L)]			-0.06	-1.67	0.384	213.69	-0.13	0.01	-0.48
gamifiedElement [Avatars (A)]			0.02	0.49	0.994	208.19	-0.05	0.08	0.13
gamifiedElement [Narrative Content (N)]			0.06	1.70	0.384	207.03	-0.01	0.12	0.44
gamifiedElement [Combination (PBLA)]			0.00	0.06	0.994	208.37	-0.06	0.06	0.01
gamifiedElement [All Elements (PBLAN)]			0.01	0.22	0.994	210.22	-0.06	0.07	0.06

Discussion

Summary of Research focus

Implications

Limitations

This study has several key limitations that must be acknowledged. Firstly, the reliance on self-reported data from students may lead to potential biases and inaccuracies in the findings. Previous research suggests that objective measures, such as sensor-based tracking, could provide more reliable data (Woolf et al., 2010). Another significant limitation arises from the demographic and location constraints of our sample. The majority of participants were recruited from the computer science building on a technical campus, which may not provide a diverse representation of the general student population. Additionally, the customization options for avatars were limited, lacking diverse representations such as Hijabs or beards, as noted by participants. This limitation may affect the engagement and identification of users with the avatars, potentially skewing the results regarding the impact of gamification on different genders. The narrated content of the gamified elements could also be not engaging enough, being confined to a small portion of the screen without integrating characteristics, abilities, or dialogues that could enhance user interaction. This might have contributed to some participants opting to disable gamified elements, thus not experiencing the intended gamified environment fully. Furthermore, the design of the study involved three iterations per participant, which might have led to habituation effects. These effects could influence the outcomes in terms of learning environment adaptability, anxiety, motivation, and self-efficacy, thus potentially diminishing the study's ability to measure these constructs accurately over time. Finally, the lack of sufficient individualized feedback post-study was highlighted as a concern. Future iterations of this study should consider incorporating mechanisms for more personalized and actionable feedback to enhance the learning and adaptation process for participants. Despite these limitations, the findings provide valuable insights into the intersection of gamification and gender, suggesting avenues for future research and practical applications in educational environments.

Future Research

As highlighted in the introduction, the exploration of individual characteristics in the selection of gamified elements within learning environments requires further investigation. This thesis has laid foundational insights into how gender influences engagement with gamified systems. However, other dimensions such as age, culture, and notably, the educational level (ranging from school-level to higher education and adult learning) merit in-depth exploration to comprehensively understand the dynamics at play.

Moreover, while the study's learning environment provided a basic platform, it does not directly represent the probable application of gamified elements. As noted earlier, gamified elements are prevalently integrated into Intelligent Tutoring Systems. Therefore, conducting studies that focus on gamified ITS can yield more pertinent insights into their efficacy and application. As the modelling of such systems, even without gamification, is quite extensive and customizable per learner itself, for it to work properly, it should be tested in an ITS.

Additionally, the temporal scope of this study was limited, addressing only short-term interactions. Prior research has established the significance of longitudinal studies in this domain (Dehghanzadeh et al., 2024; Oliveira et al., 2023). Extending research timelines to span multiple semesters would provide a more robust understanding of the long-term impacts of gamification on learning outcomes and student engagement. Such extended studies are quite challenging in every research area, but crucial for observing changes in learner stategies and behaviour and the sustainability of gamification benefits over time.

In conclusion, advancing research in these areas will not only enrich our understanding of how different groups respond to gamified learning but also enhance the design and implementation of educational technologies that are inclusive and effective across diverse learning environments.

Conclusion

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