Lehren und Lernen mit Intelligenten Systemen

Bachelorarbeit

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

Robin Gebert

Studiengang:	Informatik - M. Ed. (Erw)
Prüfer/in:	Jun.-Prof. Dr. rer. nat. Maria Wirzberger
Betreuer/in:	Nadine Nicole Koch, M.Sc. Niklas Meißner, M.Sc.
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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.

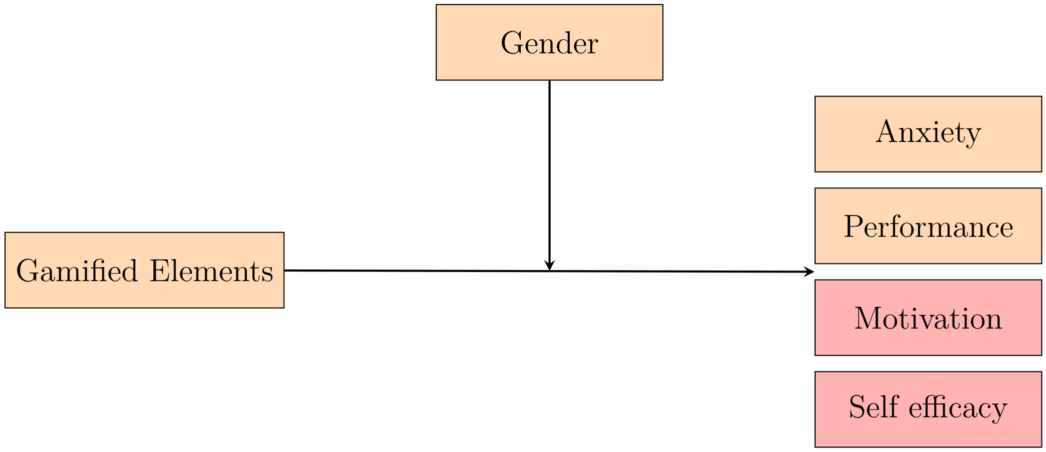
The design of virtual classroom environments significantly influences gender disparities in computer science courses, impacting both course selection and anticipated success. Research by Cheryan et al. (2011) shows that altering the design of virtual classrooms from stereotypical computer science environments 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 independent variables were 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 a control group with no gamified elements. 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 not 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).

Although self-efficacy and motivation were also assessed (Chen et al., 2001; Guay et al., 2000) through subsequent questionnaires, these variables were not analyzed within the scope of this bachelor thesis. The collected data for self-efficacy and motivation are intended for use in the doctoral dissertation of **Nadine Koch**. 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. The sequence and consistency of the testing procedure, including the series of questions asked in the gamified digital learning environment were always maintained to ensure the reliability of measurements and comparability of results across the various stages of the experiment.

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, so both rooms are equipped with the same furniture and lighting and are furnished very dry, like a typical software laboratory.

Virtual environment

The software used in this study was build by the author using SvelteKit in frontend and KTor in backend. Its UI is designed after the study by Albuquerque et al. (2017). On the iMac's 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 to give an overview and explain the data collection to the user. A personal detail screen to collect 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.

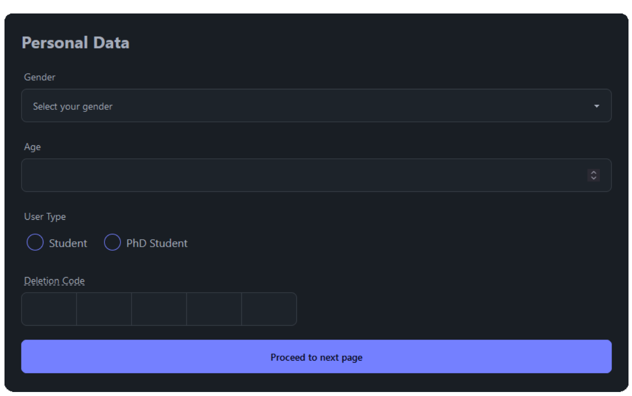


Figure 1

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.

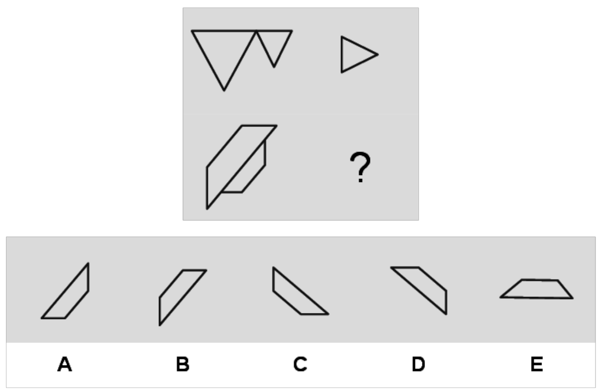


Figure 2

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

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

Leaderboards : A list of participants and scores, including the current participant. The other players shown are not real.

Badges : An array of four badges that are awarded for 1, 5, 10 and 18 correctly answered questions.

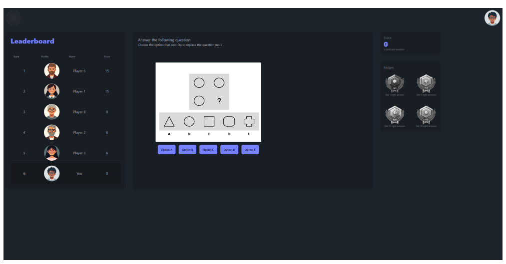
Avatars : A small avatar that is shown in the top right corner of the screen and on the leaderboard. To increase identification with the avatar further, the participants were asked to choose one of 15 different avatars before the iteration.

Narrated content : Narrated content is shown in the bottom right corner of the screen.

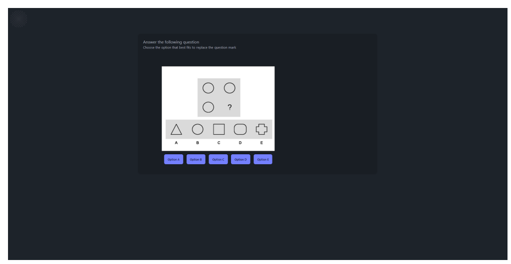
It is presented as a speech bubble with an avatar next to it, in case avatars are enabled. It shows a random praise or encouragement sentence every three questions.

Points : A counter next to the question frame shows the current points. One point is awarded for each correctly answered question. THe narrated content is shown every three questions.

After answering one question the next question has a one-second delay which increases to four seconds if narrated content is shown.



(a) *The Digital Learning Environment with Points, Badges, Leaderboards and Avatars enabled*



(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).

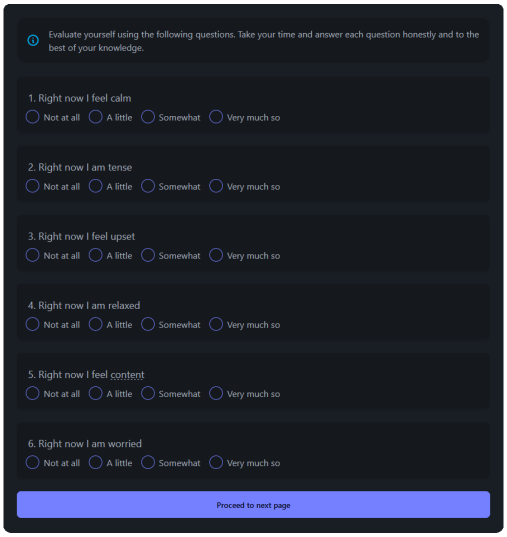


Figure 4

The anxiety questionnaire

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

Procedure

Participants were 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 were directed to select both a room and a computer. The initial screens presented were those seeking consent and outlining the study details. Subsequently, participants inputted their data, leading into a series of three questioning phases. Each phase initiated with the gamified learning environment, followed by three questionnaires, and concluded with a data submission interface. Participants were 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 were acknowledged for their contribution and compensated with the 15€.

Scoring

Scoring was done in R manually. The data was cleaned up before the analysis. The scores for the different conditions were calculated as follows:

Performance was calculated as the sum of the correctly answered questions divided by all questions. If this value was below 0.25 the particular dataset was excluded from the analysis.

STAI was calculated using the formula provided by Marteau and Bekker (1992). As participants had answers from "Not at all" to "Very much so" the answers are represented by numbers from zero to five. As the original test has 20 questions, weights according to Marteau and Bekker (1992) were applied to the answers. Negative weights were applied for negative questions like "Right now I am worried".

New GSE was calculated using the formula provided by Guay et al. (2000). The mean of the number representation of the answers was calculated.

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