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

Robin Gebert, Nadine Koch, Niklas Meißner, and Jun.-Prof. Dr. rer. nat. Maria Wirzberger

University of Stuttgart

Abstract

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Keywords: Gamification, Gender

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Theoretical Background

Gamified digital learning environments

The program used in this study can be best described as a gamified digital learning environment (GDLE). This term encapsulates any digital platform designed for educational purposes that incorporates game-like elements to engage users. While Intelligent Tutoring Systems (ITS) represent a sophisticated subset of digital learning environments, characterized by their ability to dynamically adapt to a learner's needs, the ultimate goal of this project is to develop an ITS. An ITS can be defined as "any computer program that can be used in learning and that contains intelligence" (**freedmanLinksWhatIntelligent2000**). It supports a learner's journey through a specific knowledge domain by generating tailored tasks that resonate with individual learning needs (**gonzalezGamificationIntelligentTutoring2014**). 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 for both the machine and the user (**psotkaIntelligentTutoringSystems1988**). Typically, an ITS integrates three interlinked models: the student model, which maintains information about the user; the domain model, which holds the knowledge base and structure of the learning material; and the tutor model, which orchestrates interactions with the student and determines task assignments in alignment with learning objectives (**gonzalezGamificationIntelligentTutoring2014**; **freedmanLinksWhatIntelligent2000**).

With the increasing application of gamification in educational technologies, the role of GDLEs, especially those aspiring to evolve into ITS, is becoming more significant. Incorporating gamified elements not only enhances the engagement and motivation within

the ITS but also necessitates mechanisms for tracking progress, such as content unlocking (**gonzalezGamificationIntelligentTutoring2014**). The evolving landscape of ITS research also includes emotional and relational dynamics, linking student emotions and teacher-student relationships to learning efficacy and motivation (**woolfAffectiveTutorsAutomatic2010**). These insights have led to the development of digital companions 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 (**woolfAffectiveTutorsAutomatic2010**).

Gamification

Gamification can be defined as "the idea of using game design elements in non-game contexts" (**deterdingGameDesignElements2011**) to further increase motivation and user activity within interaction design (**deterdingGameDesignElements2011**). These game-design elements "gamified elements" are elements often found in classical games. Often used elements are points, badges, leaderboards and avatars, other mechanisms include content unlocking, storytelling and memes (**zainuddinImpactGamificationLearning2020**). Often those elements are used specific constellations like the PBL triad described by **werbachWinHowGame2012**, 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 (**werbachWinHowGame2012**). 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 (**werbachWinHowGame2012**). 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 **sailerGamificationLearningMetaanalysis2020**. The use of gamified elements showed positive outcomes in multiple studies, in general (**hamariDoesGamificationWork2014**) as well as in education specific contexts (**sailerGamificationLearningMetaanalysis2020**). But gamification, especially some elements like leaderboards, can also lead to negative outcomes. Leaderboards, while motivating through comparison, have been reported to demotivate participants (**almeidaSystematicMappingNegative2021**). "Pavlovication" as **klabbersArchitectureGameScience2018** 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 (**klabbersArchitectureGameScience2018**). Some studies also suggested that gamified learning platforms also lack individualism regarding choice and display of gamification elements, resulting in discomfort and negative emotions (**santosDoesGenderStereotype2023**). To combat this missing individualism, **oliveiraTailoredGamificationEducation2023**; **dehghanzadehUsingGamificationSupport2024<empty citation>** suggest using more independent variables to taylor the use of gamification elements

Gender and Stereotype threat

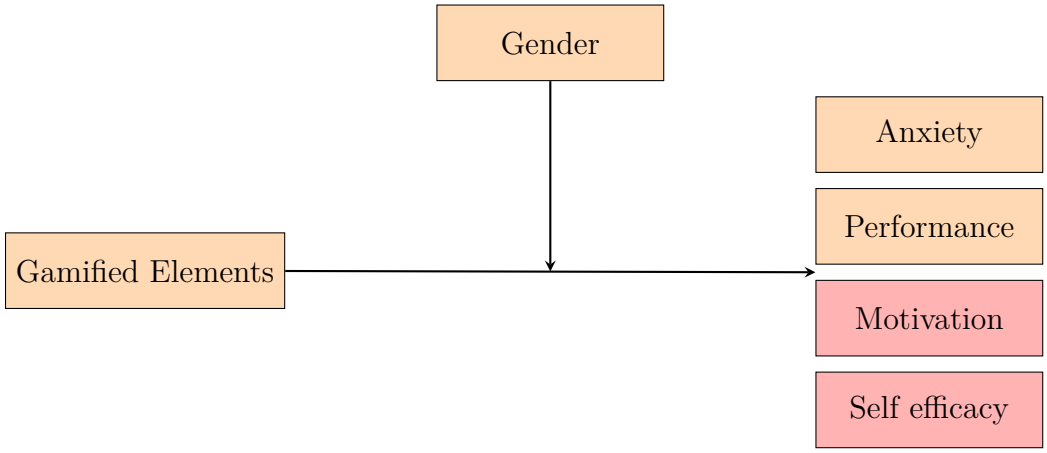
Gender, as a concept within social sciences, refers to more than the binary categorization of male and female. It encompasses a range of identities and experiences that are shaped by a complex interplay of biological, psychological, and social factors. Gender is not solely determined by biological characteristics; instead, it is increasingly recognized as a spectrum, acknowledging the presence of diverse gender identities beyond the traditional binary understanding (**lindqvistWhatGenderAnyway2021**). 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 behaviors, roles, and expectations, which are often internalized from an early age through various socialization agents like family, media, educational institutions, and peer groups (**kampshoffHandbuchGeschlechterforschungUnd2012**). 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.

Stereotype threat occurs when "one can be judged by, treated in terms of, or self-fulfill negative stereotypes about one's group". Although this study does not aim to eliminate stereotype threat it is an important factor as it can explain at least some of the differences different genders experience while studying computer science (**cheryanClassroomsMatterDesign2011**), especially regarding math (**spencerStereotypeThreatWomen1999**). Stereotype threat even leads to lower identification with academics and specific subjects (**christyLeaderboardsVirtualClassroom2014**).

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 (**dehghanzadehUsingGamificationSupport2024**). 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

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 an 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 (**marteauDevelopmentSixitemShortform1992**).

Although self-efficacy and motivation were also assessed (**chenValidationNewGeneral2001**; **guayAssessmentSituationalIntrinsic2000**) 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 seperate rooms in the cellar of a university building, one equipped with five and one with seven iMac's. As **christyLeaderboardsVirtualClassroom2014<empty citation>** 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. It's UI is designed after the study by **albuquerqueDoesGenderStereotype2017<empty citation>**. 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.

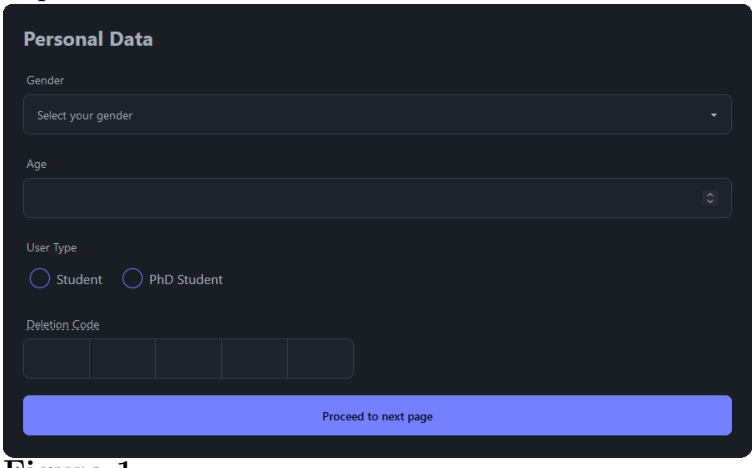


Figure 1

The personal detail 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 **albuquerqueDoesGenderStereotype2017<empty citation>**, 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.

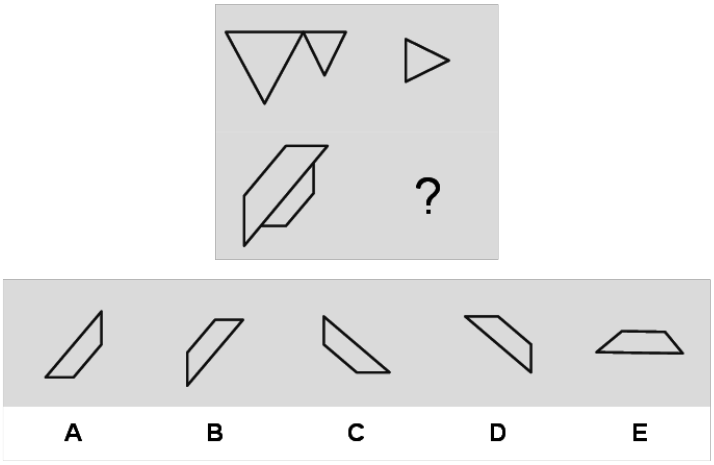


Figure 2

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 1 second delay which increases to 4 seconds if narrated content is shown.

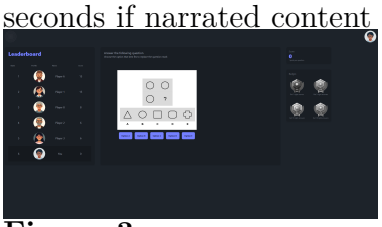


Figure 3

The Digital Learning Environment with Points, Badges, Leaderboards and Avatars enabled.

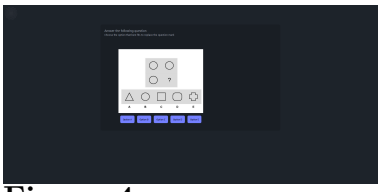


Figure 4

The Digital Learning Environment with Points, Badges, Leaderboards and Avatars 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) (**marteauDevelopmentSixitemShortform1992**), the eight-question General Self-Efficacy Scale (GSE) (**guayAssessmentSituationalIntrinsic2000**) and the 16-question Situational Intrinsic Motivation Scale (SIMS) (**chenValidationNewGeneral2001**).

Procedure and Materials

The study was conducted in two seperate rooms, one equipped with five and one with seven iMac's. The study was displayed in full-screen mode to ensure no further distractions. At the start participants were shown a consent form as at least some personal data was collected, namely gender, age and study program. Participants also had to enter

a deletion code in order to request their data's deletion after the collection.

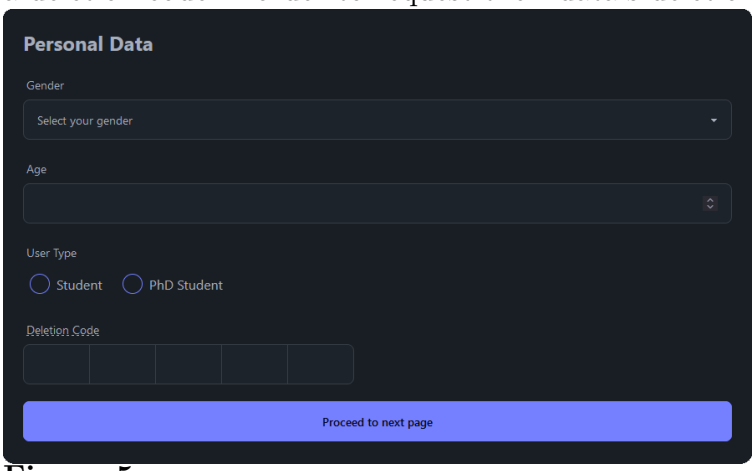


Figure 5

The personal detail collection form

Afterwards the study proceeded to three iterations of 20 questions each, that are based on Progressive Matrices used by **albuquerqueDoesGenderStereotype2017<empty citation>**. Every iteration was followed by three questionnaires for anxiety, motivation and self-efficacy. Then a data submission dialog guided the participants to the next iteration.

Question items

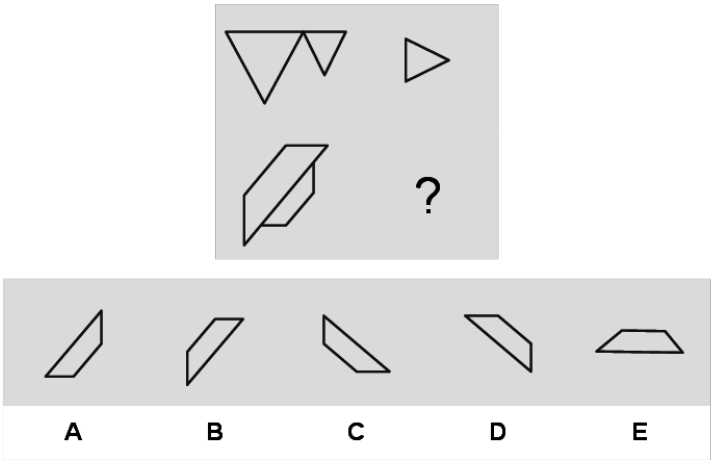


Figure 6

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

To generate 60 questions out of the 20 from**albuquerqueDoesGenderStereotype2017<empty citation>**, the questions were slightly altered by this author. These questions are embedded into the digital gamified learning environment.

Gamified Digital Learning Environment

The Environment used a combination of different Gamified Elements for each iteration.

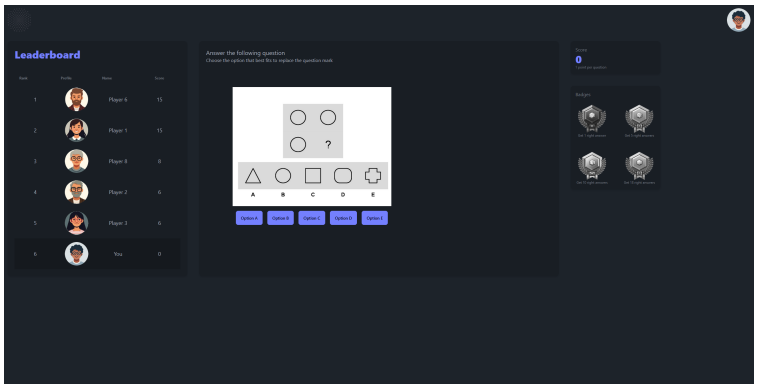


Figure 7

The Digital Learning Environment with Points, Badges, Leaderboards and Avatars enabled.

Scoring