A Gamified Application for Test Anxiety in Computer Science Education: A Pilot Study

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Abstract

This paper presents *YoungMind*, a gamified digital application designed to assist Computer Science undergraduate students in practicing anxiety-reduction techniques for managing test anxiety, particularly when they face programming tests. A pilot study involving 15 students was conducted to explore the potential of YoungMind application for supporting test anxiety management and evaluating the effectiveness of its game elements. The study compared two groups: one using the gamified version and the other using a non-gamified version with identical content. Student feedback gathered through a user experience survey indicated that the gamified version was more engaging and facilitated easier learning and practice of anxiety-reduction skills, suggesting that YoungMind may offer benefits in helping students manage test anxiety.

Keywords: Digital gamification, Test anxiety management, Computer Science Education

1. Introduction

Test anxiety, the stress or fear experienced before or during exams [25], is a prevalent issue among undergraduate students that often contributes to reduced academic performance and increased stress levels [1], [21].

Among various study disciplines, Computer Science (CS) is particularly affected by test anxiety, as students face a range of academic challenges such as complex coursework, demanding assignments, and exams, all of which contribute to high anxiety levels and increased dropout rates [5]. Programming-related courses, specifically, including those with timed coding assessments, practical labs, and algorithm design tasks, can further heighten students' anxiety and negatively affect both their test preparation and performance [4].

Gamification, the use of game elements in non-game contexts [9], has emerged as an effective strategy to enhance motivation, engagement, and learning outcomes. Particularly, incorporating game elements such as points, leaderboards, badges, levels, and avatars, has shown potential in improving students' learning experiences [6]. These gamified applications, delivered through mobile, computer-based, or web platforms, have also proven to be effective in helping students to manage anxiety.

However, most of the digital learning approaches presented in previous research have been broad in scope [7]. For instance, interventions often focus on generalized mental health conditions, such as general anxiety or depression, and are evaluated on broader populations, which suggests that they may not directly address the unique test anxiety challenges faced by CS undergraduates. This gap highlights the need for innovative and interactive approaches specifically designed to support CS students in managing test-related anxiety [23].

This research explores how gamification, when integrated into digital learning solutions, can help CS students in managing test anxiety, particularly in the context of programming assessments. This paper presents an initial evaluation of a newly developed gamified application that combines game elements with anxiety-reduction skills. The objective of this preliminary study is to gather user perceptions on the application's game design, usability, and potential to reduce test anxiety, thereby informing future iterations of the application and guide future studies involving direct test anxiety measurement and performance outcomes.

The remainder of this paper is structured as follows: Section 2 presents related work on using gamification to address test anxiety. Section 3 discusses the application's design and development. Section 4 presents the evaluation methodology, followed by the results and discussion in Section 5, and the conclusions in Section 6.

2. Related Work

Various student populations, spanning from primary schools to tertiary education, have been the subject of research on digital mental health interventions that incorporate gamification to address anxiety, particularly test anxiety. In university settings, studies across diverse academic disciplines have shown promising results, highlighting the potential of gamified approaches to alleviate test anxiety, and suggesting potential directions for future research in this area.

Mavridis and Tsiatsos [17] found that a 3D game-based assessment approach helped CS students lower their test anxiety and perform better compared to traditional examination methods. Similarly, Mallas et al. [16] developed a gamified platform called PLAY that helped to increase awareness about anxiety and coping strategies among software engineering students. Li et al. [15] and Tovar et al. [24] research showed that web-based gamified interventions improved mental health literacy, alleviated test anxiety, and enhanced motivation. Additionally, Arkün et al. [3] found that gamified assessments enhanced learning and reduced anxiety, demonstrating the potential of gamification as a beneficial educational tool.

In addition, game-based platforms such as Kahoot and Quizizz have been studied in the context of test anxiety, with findings indicating that these tools create an engaging and interactive learning environment while reducing students' anxiety during assessments [2] [18]. Moreover, mindfulness applications such as Headspace and Calm, which feature gamified elements, have been shown to reduce general anxiety and stress. Although not specifically designed for test anxiety, their effectiveness in promoting relaxation and emotional regulation suggests potential benefits for students preparing for examinations [10] [17].

Despite the promising results of gamified interventions, there is a noticeable gap in research specifically targeting test anxiety challenges among CS students. Most recent studies focus on broader academic populations, general anxiety scenarios, or the gamification of assessments, which may not be practical for every university assessment and could potentially have negative consequences if not appropriately implemented [14]. Additionally, no existing studies have integrated both study strategies and mindfulness techniques into a single gamified intervention to address test anxiety. Accordingly, to bridge this gap, our study aims to develop a digital gamified solution specifically designed to help CS undergraduates manage test anxiety, offering support that extends beyond the assessment process.

3. Application Design

3.1. YoungMind Application

YoungMind was developed as a support tool for exam preparation and test anxiety management. It is a digital, gamified application that helps students manage test anxiety by providing a platform to learn and practice anxiety-reduction skills. It aims to reduce the stress and anxiety associated with preparing for programming-related assessments, particularly computer-based tests involving coding, debugging, and problem-solving tasks.

The requirement-gathering process for designing the application began with a systematic literature review of previous studies on similar gamified digital applications developed to reduce test anxiety among CS students. Furthermore, a preliminary survey was conducted (n = 129) with CS undergraduates to identify the key stressors related to tests in CS education.

The findings from this survey demonstrated that computer-based programming lab tests are a significant source of stress for students, contributing to test anxiety. Additionally, the survey identified student preferences regarding the design and features of a supportive application. Insights were gathered on the gamification elements that students found most engaging and the anxiety-reduction skills they wanted to develop, which could help them manage test anxiety during the exam preparation process.

The application was developed as a web-based platform with a mobile-responsive design using the MEAN stack (MongoDB, Express.js, Angular, and Node.js). It was hosted on a university server to ensure secure access for participants**.**

3.2. Structure and Content

The structure and content of the YoungMind gamified application were developed based on test anxiety treatment strategies identified in previous research. These strategies are typically categorized into three approaches: cognitive, affective, and behavioral [10].

Cognitive treatments focus on addressing negative thoughts and reactions related to ability and performance in evaluative situations [21]. Affective treatments target physiological and emotional arousal symptoms, while behavioral treatments address issues such as poor study habits, procrastination, avoidance, and escape behaviors associated with test anxiety [26].

Accordingly, the YoungMind application's structure was designed to include two main modules: Exam Preparation and Emotional Support (Figure 1). The Exam Preparation module follows behavioral strategies and skill deficit approaches from past studies [6], [24], which the preliminary survey findings also highlighted as useful skills for students. It includes three games, each targeting a specific study skill: (i) reviewing past lab notes, (ii) creating mind maps, and (iii) developing question-and-answer sets. Within the game application, these activities are referred to as *Lab Revision Mastery*, *Mindmapping Mastery*, and *Questions Mastery*, respectively.

The Emotional Support module integrates cognitive and affective strategies to help students manage test-related stress. It includes two mindfulness skills: (i) guided breathing exercises and (ii) journaling. These are referred to as *Breathing Mastery* and *Journaling Mastery* in the game application and were designed to encourage regular practice, enhance motivation, and develop a positive mindset in preparation for tests.

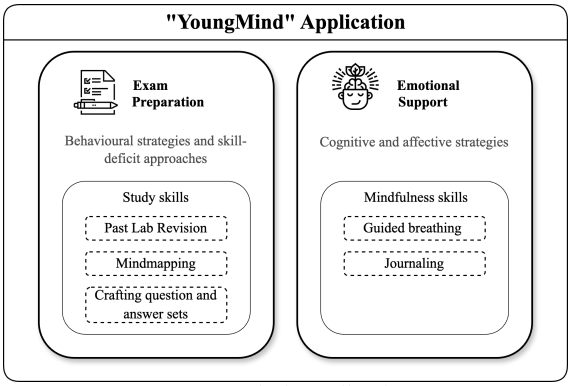

Fig. 1. YoungMind Application Structure

3.3. Game Design and Play

Selecting the most appropriate game elements and strategies for gamification is essential in game design, as these choices significantly affect the effectiveness of the game experience and user engagement [13]. After analyzing student preferences from the preliminary survey and considering the usage and effectiveness of game elements in

previous research, the application incorporated experience points (XP), badges, challenges, avatars, and a storyline (see Table 1).

Table 1. Usage of selected game elements in the application and their intended purposes

Game Elements	Intended Purpose
Challenges	Tasks for students to complete, often related to practicing specific study skills and mindfulness skills.
Points and badges	To reward students for their achievements, such as completing challenges (e.g., practicing suggested skills), and for motivational purposes.
Avatar and storyline	To personalize the user experience and identity in the application and to create a sense of immersion in the game.

In designing the game application, frameworks such as Game Elements Hierarchy by Werbach and Hunter [25] and the MDE framework proposed by Robson et al. [20] were considered to ensure a structured and effective use of these elements.

The game application is built around an ancient Egyptian storyline, using related graphics and images. Upon registration, students are prompted to select a username and an avatar from a list of Egyptian gods. The application then presents five challenges (Figure 2.a), each corresponding to three study skills and two mindfulness skills, allowing students to select and play at their own pace.

Each game was structured into two sections: "Learn" and "Play". The "Learn" section (Figure 2.b) provides tips, supportive images, and videos, all narrated by an Egyptian god figure, aiming to engage students in learning the specific skills. Following this, students could transition to the "Play" section to apply and practice the skills they had learned. Experience points are awarded for each practice session, and students receive two distinct badges, “Beginner” and “Master”, based on the frequency of their practice sessions. For example, in the "Labs Revision Mastery" game (Figure 2.c), students could log their daily lab revision activities and earn experience points. By reaching certain milestones, such as completing a number of revision sessions, students are awarded badges, recognizing, and rewarding their progress in mastering the skill. These badges are displayed in the user profile (Figure 2.d).

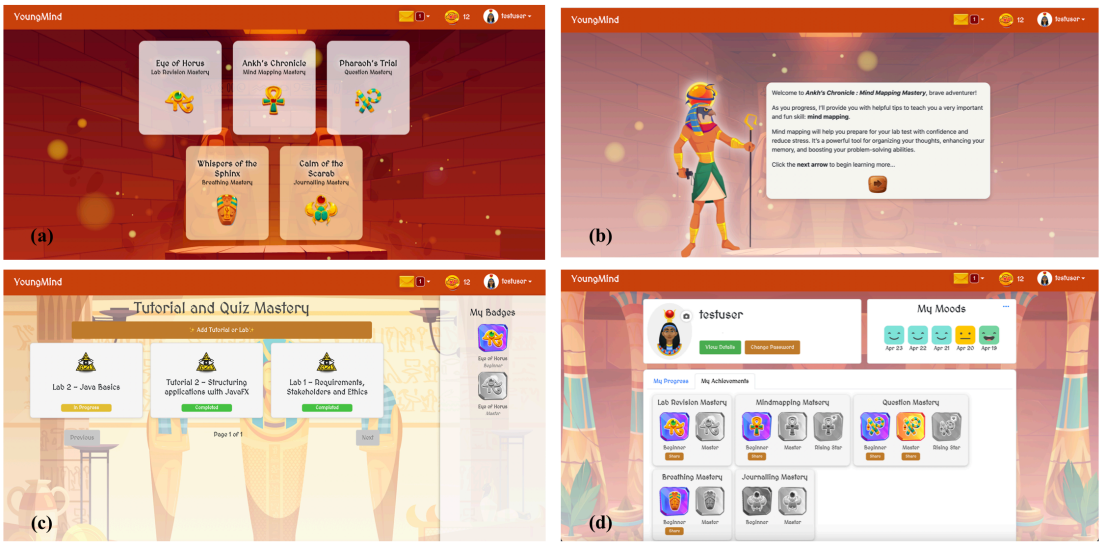

Fig. 2. (a) Homepage displaying five challenges related to skills, (b) Interface for the Mind mapping Mastery "Learn" section, (c) Interface for the Lab Revision Mastery "Play" section and (d) User Profile showing user details and achievements (badges)

4. Evaluation Methodology

A pilot study was conducted in a CS second-year course at the University of Canterbury to evaluate the application's content, its game elements' effectiveness, and the overall user experience. The study was conducted three weeks prior to the programming lab test, which was an assessment item of the course.

Two sample groups were involved: the experimental group used the YoungMind gamified application, while the control group used a non-gamified version explicitly developed to isolate the impact of gamification on students' preparation and test anxiety. A total of 15 students volunteered to participate in the study. They were randomly allocated to the gamified group (n = 8) or the non-gamified group (n = 7).

Three weeks before the scheduled programming lab test, participants were given access to the application assigned to their group. They had unrestricted use of the application throughout the preparation period. Instructions were provided on navigating and using the application, along with occasional reminders encouraging engagement during their free time. After completing the lab test, participants were invited to complete a user experience survey to reflect on their interaction with the application during their test preparation phase.

The user experience survey consisted of three sections: (1) six rating scale questions assessing students' perceptions of the impact of learning and practicing skills on test preparation and anxiety management, (2) seven rating scale questions evaluating the effectiveness of the game design, along with one question focused specifically students' perceptions of the game elements, and (3) the 10-item System Usability Scale (SUS) [12] to evaluate the application's perceived usability.

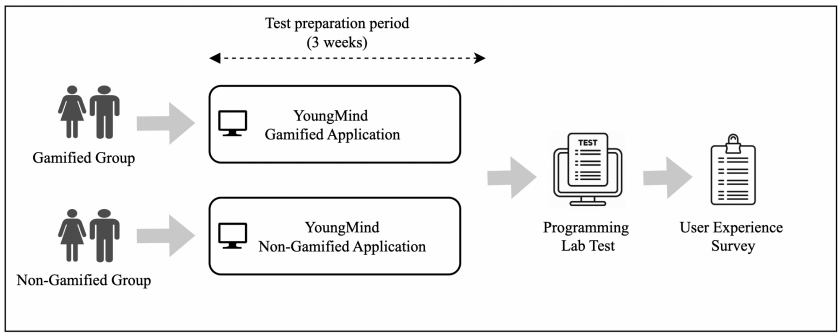

Fig. 3. Pilot Study Design

5. Results and Discussion

The data gathered from the user experience survey were subjected to descriptive statistical analysis to evaluate participants' opinions. Due to the small sample size, inferential statistics were not performed.

5.1. Impact of the skills in test preparation and anxiety management

Participants rated a series of statements (see Table 2) about the skills they learned and practiced, using a 7-point Likert scale (1 = Strongly Disagree, 7 = Strongly Agree). Median ratings were calculated to compare the gamified and non-gamified groups.

Both groups found learning the skills through the application equally enjoyable (5.0). However, the gamified group felt more motivated to learn and practice the techniques (5.0) compared to the non-gamified group (4.0). They also rated the skills as easier to understand and apply and less overwhelming to learn or practice (5.5 compared to 5.0). Importantly, participants in the gamified group felt that learning and practicing study skills helped reduce their test anxiety more effectively (5.5) than those in the non-gamified group (4.0). However, both groups gave similar ratings regarding the effect of mindfulness skills on test anxiety management (4.0). It can be assumed that incorporating more incentives, such as unlocking reflective prompts, may encourage more consistent practice and help students better recognize the benefits of mindfulness in managing test anxiety.

Table 2. Perceived impact of learning and practicing skills on preparation and anxiety management (Median Rating)

Statement	Gamified	Non-gamified
Learning the skills through the application was enjoyable.	5.0	5.0
I felt motivated to learn and practice the skills.	5.0	4.0
The skills were easy to understand and apply.	5.5	5.0
The skills were not too overwhelming to learn or practice.	5.5	5.0
Study skills helped reduce my test anxiety.	5.5	4.0
Mindfulness skills helped reduce my test anxiety.	4.0	4.0

Overall, these results highlight the positive influence of gamification on learners' engagement and learning experience. The increased motivation and ease of learning in the gamified group suggest that the game elements may have helped foster a feeling of competence and progress. In addition, by embedding game elements in skill development, it can be assumed that the application has made acquiring and practicing skills feel less like a chore and more like an achievable and rewarding activity, supporting both preparation and anxiety management.

5.2. Game Design and Elements

Participants in the gamified group (n = 8) evaluated the perceived impact of game design and game elements on user experience and engagement (see Figure 4). Six participants reported that the game design was attractive (Q1), while seven agreed that the game rules were clear and easy to understand (Q2). Similarly, seven participants felt that the game objectives were clear and easy to follow (Q3). Nearly all participants found the progression of the game, including its narration and content, to be logical (Q4), and seven reported that the storyline was easy to understand (Q5). The complexity of the game (Q6) was also considered appropriate by seven participants. However, only five participants reported feeling involved in the game experience (Q7), while two disagreed. This suggests that while the functional aspects of the design were strong, the storyline could be further developed to create a more immersive and engaging experience.

The perceived impact of the five game elements (Figure 5) integrated into the application on participants' engagement, learning, and practice of study and mindfulness skills was assessed using a 10-point scale (1 = lowest positive impact, 10 = highest positive impact). Median scores were calculated for each element. Results revealed that the most positively rated task-based game element was the challenges (6.5), followed by experience points (XP) (5.0) and badges (4.5). It is likely that these task-based game elements contributed to a sense of accomplishment and visible progress, which play a key role in promoting skill acquisition and supporting anxiety management during test preparation.

The avatars received a moderate rating (4.5), indicating some value in enhancing personalization and engagement. In contrast, the storyline received the lowest rating (3.5), suggesting that task-based game elements are more likely to engage students and enhance the learning experience.

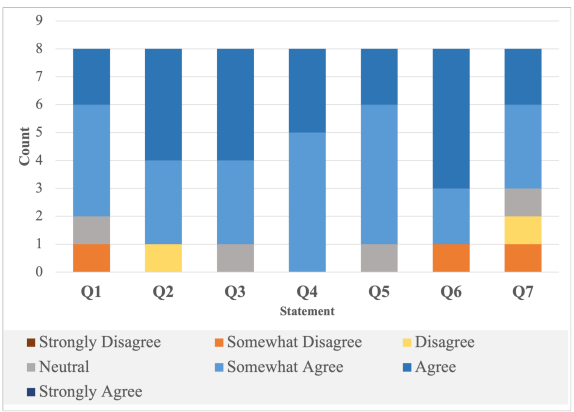

Fig. 4. Perceived Impact of Game Design on User Experience and Engagement

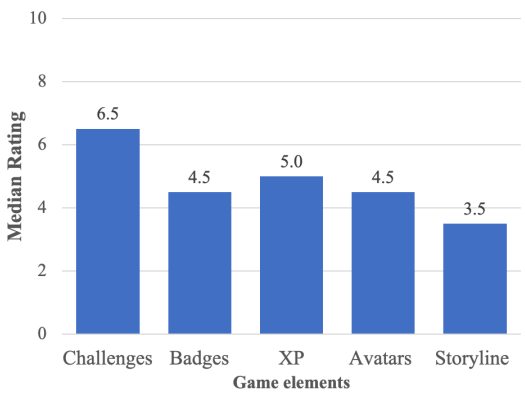

Fig. 5. Perceived Impact of the Game Elements

5.3. System Usability

The average SUS score was reported as 66.56, which is close to the widely accepted industrial benchmark of 68. This suggests that while the application is generally usable, there is still potential for improvement, particularly considering this is a pilot version.

6. Conclusion

The pilot study explored the potential of the *YoungMind* gamified application to support students in preparing for programming assessments by helping them learn and apply anxiety-reduction skills. Although the study did not directly measure test anxiety, the gamified group reported feeling less overwhelmed and more motivated, indicating that the application may offer meaningful support for managing stress during preparation. Moreover, integrating both study and mindfulness skills appears beneficial, as students reported that these techniques helped reduce their test anxiety. Interestingly, task-based game features, such as challenges, badges, and experience points, seemed to play a role in engaging students with practice activities related to skills, which may have helped reduce test anxiety.

While results are promising, limitations include the small sample size and lack of direct measurement of test anxiety. Future research will involve larger participant groups, measure anxiety through longitudinal assessments, and incorporate standardized test anxiety measures such as the Test Anxiety Inventory (TAI) and State-Trait Anxiety Inventory (STAI). Further studies will also examine how specific game design and usability features influence user experience and anxiety levels.

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