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Gamifying Assessments in Medical Education: A Novel Approach to Tackling Test Anxiety in Medical Students

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ABSTRACT

Introduction: Test anxiety is a specific type of anxiety that typically occurs during assessments and may compromise students' academic performance. The use of gamification in assessment has the potential to reduce test anxiety.

Aims &Objectives: This study aims to provide an understanding of the potential benefits of gamification as an intervention in formative assessments to reduce test anxiety in medical students. The objective of this study was to investigate the effect of gamification on the academic performance and test anxiety scores of medical students during formative assessments.

Place and Duration of Study:The study was conducted at Shifa Tameer-e-Millat University and Bahria University Medical and Dental College from July to December 2022

Material &Methods: The present mixed-method study used Nist& Diehl Patrick-Henry-Community-College (PHCC) questionnaire to measure test anxiety in 251 medical students of Year 1&2 MBBS after formative MCQ assessments based on the Biochemistry course related to the structure andMetabolism of carbohydrates delivered during their respective modules using gamified and non-gamified online applications in the quantitative phase. Qualitative data was collected through interviews with students based on their test anxiety scores.Sciences (SPSS) version 26.0 was used to analyze the quantitative data, a p-value of ≤0.05 was considered significant.

Results: Mean anxiety scores of male students in all groups were significantly lower than female students. There was no significant difference in the test anxiety score of students taking assessments through gamified and non-gamified assessment tools.

Conclusion: Female students reported significantly higher anxiety scores both in gamified and non-gamified formative assessments. There was no significant difference in the test anxiety scores of students taking assessments through gamified and non-gamified assessment tools. Qualitative analysis revealed a positive effect on the motivation of the learners using gamified assessment tools.

Keywords: Test anxiety; gamification; formative assessment; engagement; motivation.

INTRODUCTION

Test anxiety is a well-known phenomenon thatmay affect many students in academic settings and is often associated with compromised performance in assessments[1]. Test anxiety has been frequently documented in medical students during high-stake assessments[2]. Test anxiety manifests in many ways and may even induce physical symptoms in extreme situations. Several interventions including relaxation techniques, cognitive-behavioral therapy and mindfulness-based practices have been proposed to reduce the effects of this confounding factor during assessments[3]. These interventions however are time-consuming and may require high commitment from faculty and students. Furthermore, these practices may not be suitable for all students, especially those who are reluctant to seek help due to stigma and may have difficulty accessing these resources[4].

Gamification which is the application of game dynamics and components has recently gained popularity as a promising intervention to enhance student motivation, engagement and learning outcomes[5].The use of gamification to teach complex concepts and enhance problem-solving, critical

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thinking and decision-making abilities has been extensively researched and documented[6]. However, the magnitude of the effect of reduction in test anxiety during assessments using gamification has not been fully explored[7].In medical education, both high-stake summative (assessment of learning) and low-stake formative(assessment for learning) assessments are being used for curriculum delivery[8]. The low-stakes nature of formative assessments may create an enabling environment for learning that allows for the evaluation of the efficacy of interventions including gamification during assessments[9].The absence of anxiety or stressors in formative assessments may enable educationists to obtain an accurate understanding of the effects of gamification on test anxiety and learning outcomes.

MATERIAL AND METHODS

A mixed-method sequential explanatory design was employed to explore the effect of gamification on test anxiety scores in medical students during formative assessments. The quantitative phase of the study was followed by the qualitative phase. The study was approved by Institutional Review Board & Ethics Committee of Shifa Tameer-e-Millat University and Bahria University Medical and Dental College [Ref: IRB # 048-22, ERC 51/2022].

Study Groups:
The study was conducted at Shifa Tameer-e-Millat University and Bahria University Medical and Dental College from July to December 2022.
For the quantitative phase, a total of 251 medical students from Year 1 and Year 2 were randomly assigned to one of four groups. Software-generated random numbers were allocated to each student participating in the study. Lottery method was used to randomly assign participants of each year in either study group. Two groups, one each from Year 1 and Year 2 completed a formative assessment using gamified application Quizizz, while the other two groups, one each from Year 1 and Year 2 completed the same formative assessment using the quiz feature of the non-gamified app, Google forms. The formative assessments were conducted using Multiple Choice Questions (MCQs) from theBiochemistry course related to the structure and Metabolism of carbohydrates which was delivered inthe respective modules of both Year 1 and Year 2.The participating students in the study were from diverse backgrounds and were selected based on their consent and willingness to participate in the study.

Data Collection Tools:
Test anxiety during formative assessments was measured using the Patrick-Henry-Community-College (PHCC) questionnaire.[10]The PHCC questionnaire is a valid and reliable tool that assesses test anxiety using multiple domains including physiological symptoms, worry, and cognitive interference.

Data Collection Process:
In the quantitative phase, the PHCC questionnaire was provided to all study participants for data collection after the formative assessment to measure their test anxiety levels.
In the qualitative phase, targeted interviews were conducted with a selected group of students to explore their perceptions of gamification in relation to motivation and anxiety. The criteria for the selection of participants for the qualitative phase were the test anxiety scores in the formative assessments and the willingness of students to participate in the interviews.

Data Analysis:
The Statistical Package for the Social Sciences (SPSS) version 26.0 was used to analyze the quantitative data. On the other hand, the qualitative data were expressed in percentages and analyzed using MaxQDA 2020 for reviewing, coding, and analyzing the themes.

Ethical Approval:
The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. All participants provided informed consent before participating in the study, and their anonymity and confidentiality were ensured throughout the study.

Statistical Analysis:
The normality of the quantitative data was assessed using Shapiro-Wilk's test, and statistical significance was set at a p-value of ≤ 0.05. The continuous variables were presented as the Mean ± Standard Deviation. Numerical variables were compared using the Student's t-test, while associations were explored using the Chi-square / Fisher's exact test, whichever was applicable.

RESULTS

The present study comprised a sample size of 251 participants including 140 (55.8%) first-year and 111 (44.2%) second-year MBBS students. The gender distribution was comprised of 136 (54.2%) male and 115 (45.8%) female participants. The mean ages of the participants in the first and second

year of the MBBS program were 19.26 ± 1.14 and 20.16 ± 0.96, respectively. A majority of the participants [214 (85.3%)] were residents of hostels while a smaller proportion [37 (14.7%)] were day scholars. Among the participants, 130 (51.80%) completed the formative assessment with gamification while 121 (48.20%) completed the formative assessment without gamification.

The instrument utilized for the evaluation of test anxiety in this study was the PHCC questionnaire, which comprised of 10 items and can yield scores between 10 and 50. The formative assessment administered in an online format, was composed of 10 items, and students were allotted 15 minutes for completion. The minimum score attainable was 0, while the maximum was 10.The mean anxiety score of Year 1 male students who were assigned formative assessment with gamification (n=35) was significantly lower than the mean anxiety score of Year 1 female students with gamification (n=34); ($p<0.001$). The mean anxiety score of Year 1 male students without gamification (n=41) was also significantly lower than the mean anxiety score of Year 1 female students without gamification (n=30); ($p<0.001$). The results of the comparison of mean anxiety scores after the formative assessment of Year 1 have been summarized in Table-1.Mean anxiety score of Year 2 male students with gamification (n=32) was significantly lower than the mean anxiety score of Year 2 female students with gamification (n=29); ($p<0.001$). Mean anxiety score of Year 1 male students without gamification (n=28) was also significantly lower than the Mean anxiety score of Year 1 female students without gamification (n=22); ($p<0.001$). The results of the comparison of mean anxiety scores after the formative assessment of Year 2 have been summarized in Table-2.Chi square analysis showed significant association of male students with low anxiety levels. Association of low, moderate and high anxiety with various groups of study subjects have been summarized in Table-3.The interview transcripts of a total of 8 students were analyzed thematically. The students were representative of participants who took the assessment with and without gamification. The 'word cloud' for the qualitative results of our study has been provided in Fig-1.Initial coding of interviews from students, who took their assessment with Google forms and Quizzes revealed 163 and 180 codes, respectively. These codes were then reviewed to merge similar codes. The theoretical framework of 'Self Determination Theory' comprising of autonomy, competence and relatedness was used as a guide for inductive coding and the organization of themes[11]. Themes which were recurring but did not fit in the domains of the SDT were identified and developed into separate themes.A total of 4 interviews were analyzed before saturation was reached.

Mean Anxiety Scores	Mean ± SD (n=140)	P-Value
With gamification (n=69)	22.45 ± 6.91	0.44
Without gamification (n=71)	23.41 ± 7.74	
Male students with gamification (n=35)	18.80 ± 5.70	0.31
Male students without gamification (n=41)	20.15 ± 5.84	
Female students with gamification (n=34)	26.21 ± 6.02	0.34
Female students without gamification (n=30)	27.87 ± 7.86	
Male students with gamification (n=35)	18.80 ± 5.70	<0.001*
Female students with gamification (n=34)	26.21 ± 6.01	
Male students without gamification (n=41)	20.15 ± 5.85	<0.001*
Female students without gamification (n=30)	27.87 ± 7.86	

*= Statistically Significant

Table-1: Comparison OfAnxiety Scores In Formative Assessments With Gamification And Without Gamification (Year 1 Students)

Mean Anxiety Scores	Mean ± SD (n=111)	P-Value
With gamification (n=61)	26.93 ± 8.43	0.72
Without gamification (n=50)	26.40 ± 7.11	
Male students with gamification (n=32)	23.56 ± 7.19	0.63
Male students without gamification (n=28)	24.43 ± 6.57	
Female students with gamification (n=29)	30.66 ± 8.22	0.43
Female students without gamification (n=22)	28.91 ± 7.11	
Male students with gamification (n=32)	23.56 ± 7.19	<0.001*
Female students with gamification (n=29)	30.66 ± 8.23	
Male students without gamification (n=28)	24.43 ± 6.57	0.03*
Female students without gamification (n=22)	28.91 ± 7.12	

*= Statistically Significant

Table-2: Comparison OfAnxiety Scores In Formative Assessments With Gamification And Without Gamification (Year 2 Students)

Groups Of Students	Categories For Anxiety Scores			P-Value
	Low Anxiety	Moderate Anxiety	High Anxiety	
All Students With gamification (n=130)	39	77	14	0.59
All Students Without gamification (n=121)	32	79	10	
Year 1 with gamification (n=69)	25	41	3	0.68
Year 1 without gamification (n=71)	24	41	6	
Year 2 with gamification (n=61)	14	36	11	0.15
Year 2 without gamification (n=50)	8	38	4	
All Male students with gamification (n=67)	31	35	1	<0.001 *
All Female students with gamification (n=63)	8	42	13	
All Male students without gamification (n=69)	27	42	0	<0.001 *
Female students without gamification (n=52)	5	37	10	

*= statistically significant

Table-3: Association Of Levels Of Anxiety With Or Without Gamification

Fig-1: Word Cloud of Qualitative Data

DISCUSSION

The introduction of gamification in all types of assessments has the potential to reduce test anxiety thereby improving the learning outcomes and learning environment.[12] The demographic data of our study shows that the number of male participants was higher than the number of female participants.The mean anxiety score of female students of Year 1 after formative assessments with gamification was significantly higher than their male counterparts of the same year after taking formative assessments with gamification. Similarly, female students of the same class after formative assessments without gamification had significantly higher mean anxiety levels in comparison to the mean anxiety levels of male students after formative assessments without gamification. Our findings are in agreement with most studies that have evaluated the role of gender in test anxiety in undergraduate students and have reported the prevalence of higher trait anxiety and test anxiety in female students in comparison to male students[13].

The prevalence of higher test anxiety in females after assessments with gamification and without gamification suggests that gamification in assessments failed to reduce anxiety in a group of students more vulnerable to test anxiety and the gamification factor probably failed to improve test anxiety on its own[14].

Similar to the results of Year 1, a group-wise comparison of each category of students in Year 2 revealed that mean anxiety scores after assessments with gamification were similar to the mean anxiety scores after assessments without gamification. This is in contrast to several studies stating that gamification decreases test anxiety[15]. A previous study established the association of gamification with an increase in motivation and a subsequent decrease in test anxiety[5]. Similarly, another qualitative study conducted in university students of a post graduate course also suggests that Quizzes decreases test anxiety[16]. A possible explanation for our findings is that most existing studies compare conventional assessment methods with gamified tools such as Kahoot! and Quizziz[17]. However, our study compared two technology-enhanced assessment tools, removing technology as a confounder. Our results are thus more suggestive of the true impact of gamification on test anxiety.

As was the case with Year 1, the gender-wise comparison of Year 2 reveals that the mean anxiety scores of female students after both formative assessments with gamification and without gamification were significantly higher than their

male counterparts. These findings are in agreement with literature that suggests that female students generally exhibit higher test-related anxiety and trait anxiety in the academic setting[18].The findings also reinforce the possibility that gamification fails to reduce or alter test-related anxiety and that the females are more likely to suffer from test anxiety[19].

The overall effect of the online assessment tool on anxiety was sought by open ended questions and cues[20].The students unanimously reported that their anxiety was less than what they experienced through conventional methods[21]. However, the time limit feature of the app induced anxiety in the students. Some students said that the time limit caused stress but it was manageable. As one student described it:

'*I'm on the time limit, its kind, of sort of enjoyment if you know how to control your stress, or how to control it*.'

One student shared that the anxiety caused by the time limit caused them to make mistakes. He reflected as below:

'*Ma'am the time element because you know as I've told you before that we need to answer it quickly, because we know that if we won't be answering it quickly then we'll be getting less marks, so sometimes I just answer it quickly, without thinking, and that made my answer wrong, and therefore I do lose my points*.'

The feature of the leaderboard was also seen as a source of healthy anxiety[22] by some students as described below:

'*You just want to score more, come in the top 10 or 20, and if you don't manage to get that it will cause anxiety, it will cause minor symptoms of anxiety*.'

Another added that:

'*It is sometimes motivating and sometimes anxious*.'

As all three components of Self Determination theory are linked directly to motivation, the high sense of autonomy, relatedness and competence paired with several features of the Quizzes app reflected on the students' perception of motivation[23].The most recurrent feature promoting autonomy was the hindrance to the feeling of control by the students. All of the students interviewed viewed the time limit as stealing their freedom to attempt the questions on their own terms. One student said:

'There is a time limit on Quizzes, and on paper based, there is no time limit for each question….so I think there's if you talk about control both are different.'

While another student expressed like she was not in control, but the whole experience made up for that:

'*That there was no major element of being surrendered or controlled to this regard, because at the time when we were playing the environment provided by App was quite fun and amazing*.'

Clearly, the leaderboard was seen to motivate the students towards achieving better scores. Some students reported:

'*You always want to be on the top of the leader board you know it can't happen every time, like but it motivates you*.'

'*I think my competence is linked to my preparedness. Like in school, I was not a good student, and I knew it. But now that I study I feel more competent*.'In agreement with the existing data, the healthy competition generated by the leaderboard was also viewed as a source of motivation by the students[15].

'*So that I could maintain my rank and yeah that was something that was good and Yes, indeed it was a healthy competition*.' Another student said:

'*Like you know that I get motivated that I need to study harder now and perform better so I can stand out as well among the class you know when my name will be on top or at top 10 of the leaderboard*.'

CONCLUSION

The study concluded that there was no significant difference in the test anxiety score of students taking assessments through gamified and non-gamified assessment tools. However, a statistically significant difference was noted between the male and female students, where females suffered more anxiety when compared to male students. Gamification is a science well beyond the existing gamified platforms so the development of customized gamified platforms for medical education has the potential to reduce test anxiety in formative and summative assessments. More qualitative studies on the effect of gamification on test anxiety during summative assessments may provide useful insight regarding the effect of gamification on test anxiety.

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