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Engaging students through activity-based bingo games in immunology course: Determining students' perception and measuring its influence on academic performance

Mohan B. Sannathimmappa, Vinod Nambiar, Rajeev Aravindakshan¹

Abstract:

BACKGROUND: This study aims to evaluate how well bingo game-based activities serve as instructional tools to enhance student learning.

MATERIALS AND METHODS: This prospective cross-sectional study was approved by the Institutional Ethics Committee. The study sample size was 145 MD3 year college of medicine students for the academic year 2023–2024. The evaluation instruments included the participants' exam grades, pre-test scores, post-test scores, and feedback. The study employed a mixed-methods approach combining quantitative and qualitative research methods to investigate how students perceived and interacted with the bingo game-based activity. The data were analyzed by Statistical Package for Social Sciences (SPSS) version 26. The association between exam and post-test scores was examined using the correlation coefficient and a straightforward regression analysis. The *P* value of less than 0.05 was deemed significant.

RESULTS: The study comprised 145 students in total who completed all the tasks. The post-test scores (10.62 ± 1.73) showed a statistically significant improvement ($P < 0.01$) over the pre-test scores (6.3 ± 1.99). Most students (85–90%) thought that activities centered around bingo games were great tools for learning. Nine out of ten students said the game-based activity was engaging and enjoyable, that it inspired them to engage in group discussions, that it assisted them in identifying and concentrating on important topics, and that it improved their knowledge and helped them get ready for the final exam. Almost all the participants (>90%) suggested adding this exercise to the list of future topics. Overall, exam scores achieved by students for topics covered in the bingo-based activity (92.7 ± 4.96) were significantly higher ($P < 0.01$) than exam scores for topics not covered in the activity (83.75 ± 7.74).

CONCLUSION: Bingo game is an effective learning strategy to promote students' learning in the immunology course. Furthermore, utilizing bingo games as a formative assessment technique can significantly improve students' learning and help them achieve higher scores on summative assessments.

Keywords:

Cognition, critical thinking, education tool, gamification, peer discussion

Introduction

Gamification has taken center stage in contemporary education. Educational

gamification is an approach to teaching and learning where students compete according to predetermined guidelines.^[1,2] Gamification, or using game mechanics in the classroom, encourages pupils to

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Department of Microbiology, College of Medicine and Health Sciences, National University of Science and Technology, Sohar Campus, Sultanate of Oman, ¹Department of Community Medicine, All India Institute of Medical Sciences, Mangalagiri, Andhra Pradesh, India

Address for correspondence:

Dr. Mohan B. Sannathimmappa, Department of Microbiology, College of Medicine and Health Sciences, PO BOX: 391, PC: 321, Al Tareef, Sohar, Sultanate of Oman. E-mail: mohanbs@nu.edu.om

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learn. Students expect teachers to use technology-based teaching-learning methods that incorporate their active participation in this period of rapid advancements in modern technology.^[3,4] When contemporary technology-driven teaching-learning approaches are employed instead of teacher-centered didactic lectures, prior research has shown a significant improvement in the three learning domains of cognitive, emotional, and psychomotor learning among learners.^[5-8] Research has also demonstrated that using a mix of teacher-centered and student-centered teaching strategies guarantees that every student's demands are satisfied as the learners have different learning styles.^[9] Researchers have proposed numerous interactive teaching-learning methods including games and puzzles as effective active learning strategies.^[4,10-14] These pedagogical approaches prioritize student involvement in the learning process, foster collaborative dialogue, stimulate analytical reasoning, and thereby enhance their understanding.^[15,16]

One of the subjects taught in the pre-clinical years of medical schools is immunology. It covers both immunological disorders linked to aberrant immune system activity and the healthy operation of the immune system in humans.^[14,17] Medical students view immunology as one of the more challenging courses because it requires them to learn a lot of technical terms, comprehend a variety of concepts related to healthy immune function, and the pathophysiology of immunological diseases, and apply these concepts to clinical diagnosis. Prior research has indicated that students consider active student participation to be crucial for acquiring new concepts. The occurrence of underutilization of high-quality books in medical and biomedical science educational programs during small group sessions is evident, both in terms of quantity and quality. The underutilization appears to stem from time constraints, a lack of drive, and inadequate preparation. Since these factors are known to impede effective learning, it is important to explore strategies that can enhance the learning process.^[18] Therefore, medical educators need to use teaching-learning strategies that support learning, unlearning, and relearning, stimulate critical thinking, facilitate active learning in a fun way, and increase learners' knowledge.^[19,20] A comprehensive review of the literature revealed a wealth of creative teaching-learning strategies that medical educators around the world employ to develop students' cognitive abilities. Among them, we discovered a relatively new strategy called the bingo game-based technique that is used by only a few educators.^[18,21] Bingo game serves to boost cognitive function, enhance communication skills, and foster a critical mindset. Thus, rather than relying on passive memorizing, the utilization of a bingo puzzle game might prove advantageous as a self-learning instrument, fostering active learning and cultivating practical application, and critical thinking skills.^[18]

Nevertheless, the authors discovered throughout their literature search that none of Oman's medical schools use or incorporate the bingo game-based learning tool into their curricula. As a result, during the academic year 2023–2024, the authors implemented bingo game-based learning in the immunology course. The purpose of this study is to investigate how medical students perceive the value of learning through bingo games in an immunology course. The study also intends to quantify the extent to which learning through bingo games enhances students' academic achievement.

Materials and Methods

Study design and setting

This cross-sectional single-center prospective study was conducted at the College of Medicine and Health Science (COMHS), National University, Oman. The study was conducted for a period of six months, from September 2023 to February 2024.

Study participants and sampling

All MD3 year medical students enrolled in the 2023–2024 academic year qualified as participants, and their inclusion in the study was contingent upon their consent. Students who did not complete all the activity's components or who did not demonstrate a willingness to participate were excluded from the study.

Sample size

With the help of http://www.raosoft.com/sample_size.html, the sample size was determined. After considering 160 eligible participants with a 95% confidence interval and a 5% margin of error, the minimum sample size was calculated to be 114.

Study setting

Regular didactic lectures were used to cover all immunology topics, including innate and adaptive immunity, antigen and antibody, B- and T-cell development, the complement system, cytokines, immunodeficiency diseases, hypersensitivity reactions, autoimmunity, transplant immunity, tumor immunity, and vaccines. Then, three bingo game-based sessions covering the subjects of innate and adaptive immunity, antibodies, cytokines, hypersensitivity, the complement system, and immunodeficiency illnesses were conducted as part of the intervention. Using the bingo program <https://myfreebingocards.com/bingo-card-generator>, bingo charts were created for the aforementioned topics. A sample question and the completed, ready-to-use immunology bingo card are shown in Figure 1.

Participants were divided into groups of four in the classroom, and each group received a bingo card that had a 5 × 5 grid with one word in each box. Since the

Figure 1: A type of question and bingo card that were used in the game

| Question no. 1 | | | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|------------------|-----------------|----------------------|
| I am a large cell. I sense abnormal cells through their inability to express sufficient MHC class I molecules on their surface. I induce apoptosis of the abnormal cell by producing perforins and granzymes. I belong to lymphoid family. who am I? | | | | |
| Neutrophils | Immune complex | Lysozyme | Hepatocytes | Immunoglobulin M |
| Interleukin 8 | Immunoglobulin A | Dendritic cells | Mast cells | Lactoferrin |
| Tyrosine kinase | Granuloma | TNF-alpha | NADPH oxidase | Natural killer cells |
| Memory | Surfactants | C1-inhibitor | Langerhans cell | Immunoglobulin G |
| Eosinophils | Opsonization | Immunoglobulin E | Graves' disease | Granzymes |

word sequence was randomized, each card that was distributed to the group included grid boxes with words organized in various ways. Each word (answer) in the box has a hint or inquiry [Figure 1] that is projected onto the classroom projection screen. After discussing the question with their group members, students were to circle the right answer in the grid box that appeared on the screen. Every question had a two-minute time limit. The game went on until all the questions had been addressed. Prizes were given to the team that completed any row, column, or diagonal first to inspire the students.

All immunology topics, namely, innate and adaptive immunity, antigen and antibody, B-cell development, T-cell development, the complement system, cytokines, immunodeficiency diseases, hypersensitivity reactions, autoimmunity, transplant immunity, tumor immunity, and vaccines were covered through regular didactic lectures. Then, intervention was done by conducting three bingo game-based sessions for topics such as innate and adaptive immunity, antibodies, cytokines, hypersensitivity, the complement system, and immunodeficiency diseases. Bingo charts were prepared for the aforementioned topics by using a bingo application, that is, <https://myfreebingocards.com/bingo-card-generator>.

Feedback and assessment

To evaluate the students' past knowledge from the didactic lectures, a pre-test comprising multiple-choice questions (MCQs), fill-in-the-blank questions, and short answers pertaining to the bingo topics was given to them online a little while before the session started. Subject matter experts had created and pre-validated the form for dependability. At the end of the session, a post-test was given to evaluate the knowledge that had been gained from the bingo game. After completing all the components of the classroom activity, students were then asked to offer their opinions on the session.

The self-administered, peer-validated questionnaire was tested for reliability using Cronbach's alpha. Experts in the field also examined it and made any required changes. The questionnaire was sent to each participant via their institutional email. Each participant was briefed on the need to offer frank and critical comments. The

survey was divided into two types of questions: 1. inquiries that are left open-ended; 2. Likert scale inquiries have three possible answers: agree, neutral, and disagree. The survey's question list is presented in Annexure 1.

All responses were collected, entered in a Microsoft Excel sheet, and analyzed using Statistical Package for Social Sciences (SPSS) software version 26. Additionally, students' summative exam grades for the immunology course were extracted from the Blackboard learning management system (LMS) platform. The exam results of students for the topics covered in the bingo game-based activity were separated from those for the topics not included in the activity.

Ethical consideration

The study received ethical approval from the Ethical and Research Approval Committee of the COMHS under approval number NU/COMHS/EBS0018/2023.

Statistical analysis

Using paired T-tests, the students' pre- and post-test results were assessed using standardized answer keys, and the results were compared for statistical significance (P value < 0.05). Using a questionnaire with two question types – open-ended and closed-ended – and a 3-point Likert scale with disagree, neutral, and agree responses, the students' opinions of the activity-based bingo games were evaluated. The statistical tool for social sciences, SPSS version 26, was used to obtain the correlation coefficient between the post-test scores and the summative examination grades. The correlation coefficient was then regressed while accounting for the baseline scores using repeated measures analysis of variance (ANOVA).

Results

A total of 145 students who expressed a desire to participate and successfully completed all activity sessions were included in the study. Figure 2 depicts the pre-test and post-test scores of the participants. The post-test scores (10.62 ± 1.73) exhibited a substantial improvement ($P < 0.01$) compared to the pre-test scores (6.3 ± 1.99). Many students regarded the bingo game-based activity as a highly effective tool

that enhanced their learning process [Figure 3]. Approximately 90% of the students indicated that the bingo game-based activity is engaging and enjoyable, motivating them to actively participate, recognize and concentrate on important aspects of the topics, and consequently acquire substantial knowledge on the subjects. A majority of over 85% of the students reported that engaging in a bingo game-based activity facilitated their identification of crucial areas, thereby enhancing their preparation for the summative exam. Nearly 90% of the students recommended employing the bingo game-based activity for future subjects. Figure 4 displays the comparison of exam results for topics that were covered by bingo and topics that were not covered by bingo. The exam grades obtained by students for topics that were included in bingo-based activities were significantly ($P < 0.01$) higher (92.7 ± 4.96) compared to the exam grades obtained for topics that were not included in bingo-based activities (83.75 ± 7.74).

Discussion

We aimed to evaluate the efficacy of incorporating bingo game-based learning as a means to improve the students' learning process. Game-based learning has shown superior effectiveness in knowledge acquisition and satisfaction ratings compared to interactive lectures.^[22,23] It fosters active engagement, interpersonal communication, and practical experiences, enhancing motivation and enthusiasm for learning. Interactive games provide a comprehensive learning environment, improving fundamental life skills like collaboration and synergy.^[12,19,24] Game-based learning also enhances attentiveness, concentration, mindfulness, and memory retrieval. It provides immediate feedback, allowing learners to identify errors and rectify them.^[25] Direct instruction from teachers helps students retain concepts for extended periods and requires quick thinking, which is beneficial in various aspects of life. The utilization of game-based learning environments leads to superior rates of knowledge retention in comparison to traditional book learning methods.^[26] Prior research has shown that effective small-group work requires group interaction, active student participation, and the opportunity for students to ask questions. As a result, learners comprehend challenging subjects more easily, retain key information in memory, and attain higher levels of knowledge retention.^[27-30] In line with these facts, most of our participants indicated that the bingo game-based activity was engaging and enjoyable. They found that bingo games encouraged their active involvement in peer discussions and prompted them to think critically to arrive at the correct answer to the given question. The success of game-based learning hinges on motivation as the pivotal factor. Points and leaderboards

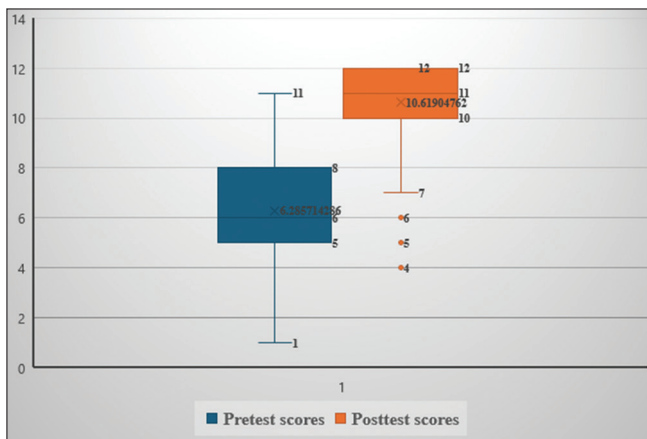


Figure 2: Comparison of the scores obtained in the pre-test and post-test

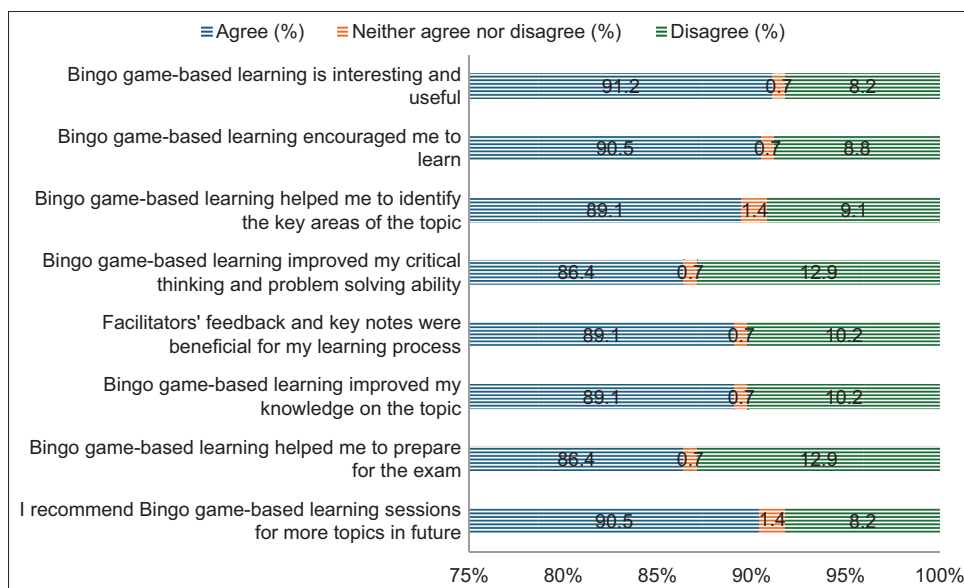


Figure 3: Feedback responses of the participants

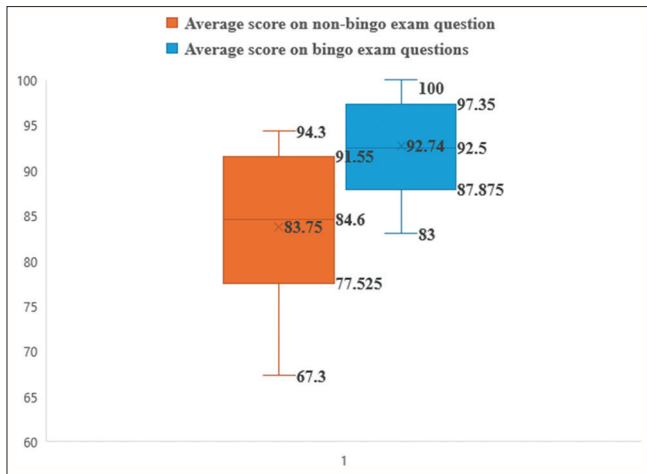


Figure 4: Comparison of exam scores between topics included and not included in the bingo activity

are commonly employed in games due to their highly motivating nature, as they encourage learners to amass points and attain top positions in rankings.^[18] In line with this, our study participants indicated gifts and prizes enhanced their motivation to achieve top scores during the session.

We also evaluated the influence of a bingo game-based activity on enhancing students' academic performance. Confronted with crucial assessments, medical students employ strategic study techniques. They seek methods to strengthen their understanding of the fundamental curriculum and prioritize study resources and techniques that directly pertain to their upcoming examinations. The constructivist theory of learning posits that optimal learning takes place when individuals actively construct or reconstruct knowledge rather than passively receiving it from instructors.^[18] Student engagement is most effectively achieved during the process of knowledge construction, wherein students actively integrate new information with existing knowledge.^[18] Haripriya *et al.* and Tietze *et al.* carried out studies that revealed that students who engaged in a bingo activity attained significantly superior average scores in their final exams as opposed to students who did not partake in bingo.^[18,31] Our findings indicate that students achieved a better mean score on the summative exam for questions pertaining to the subjects addressed in the bingo exercise, as opposed to questions on subjects not addressed by the activity. These findings indicate that the bingo game had a positive influence on students' learning, retention of information, and academic achievement.

Limitation

Our study was subject to various constraints. Initially, it was not feasible to oversee all students' discussions during the session due to the substantial number of participants. Additionally, it was challenging to ascertain

whether the students were exchanging answers during the activity. Furthermore, it is challenging to assert that the implementation of a bingo game-based learning strategy has a significant impact on students' examination results based solely on one exam. To validate this, it is necessary to incorporate bingo game-based learning strategies into a wider range of exam topics in a multicentric mode. Finally, the sample size is smaller, consisting of only a single cohort. Therefore, our study findings cannot be applied universally, and further research involving multiple groups is necessary to validate our results more conclusively.

Conclusion

This study reveals a greater level of positive feedback from participants regarding the games' effectiveness in enhancing various aspects of learning, such as acquiring knowledge and developing metacognitive abilities. Moreover, there was a significant increase in the academic performance of students in topics taught using bingo games. Thus, utilizing these active learning methods enhances students' understanding of immunology in a remarkably efficient manner.

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Conflicts of interest

There are no conflicts of interest.

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Annexure 1

| | Variable | Agree | Neutral | Disagree |
|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------|---------|----------|
| 1 | Bingo game-based learning is interesting and useful | | | |
| 2 | Bingo game-based learning encouraged me to learn | | | |
| 3 | Bingo game-based learning helped me to identify the key areas of the topic | | | |
| 4 | Bingo game-based learning improved my critical thinking and problem-solving ability | | | |
| 5 | Facilitators' feedback and key notes were beneficial for my learning process | | | |
| 6 | Bingo game-based learning improved my knowledge on the topic | | | |
| 7 | Bingo game-based learning helped me to prepare for the exam | | | |
| 8 | I recommend Bingo game-based learning sessions for more topics in future | | | |
| 9. Mention one benefit of Bingo activity-based game in the learning process of Immunology: | | | | |
| | | | | |
| 10. Mention one drawback of activity-based Bingo game: | | | | |
| | | | | |
| 11. Comments/suggestions on Bingo activity-based game for future modification: | | | | |
| | | | | |