The use of a flipped-classroom and a team-based learning (TBL) approach: replacing a standard lecture with an interactive ‘bingo’ session to deliver undergraduate content on abdominal pathology

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Abstract

**Research question:** Can a team-based learning (TBL) bingo session be used in place of a standard lecture to deliver content on abdominal pathology?

**Methods:** University ethical approval was obtained prior to starting the study. The year 1 Diagnostic Radiography cohort was split into 2 groups; each was exposed to 2 teaching activities, having previously completed an abdominal pathology workbook. Informed consent was obtained ahead of data collection. Both groups experienced two teaching activities. Group 1 attended a morning teaching session with bingo-TBL followed by a standard lecture. Group 2 attended an afternoon teaching session, with a standard lecture followed by bingo-TBL. A pre- and post-test (20 question quiz) was administered prior to, and after, the first teaching activity in both the morning and afternoon sessions. Positive and negative comments were also obtained via post-it notes.

**Results:** Utilising the paired t-test, no statistically significant differences were seen between groups’ quiz results pre- (p=0.281) or post- (p=0.428) the first teaching activity. However, both teaching activities demonstrated statistically significant increases in test results (p<0.001) when pre- and post-test results were compared. In total there were 129 positive comments and 34 negative comments. The positive qualitative comments revealed students enjoyed the interactive nature of the bingo session, enjoyed working in small groups, and appreciated the feedback on their progress. They also commented the bingo was more fun and engaging than a standard lecture. The negative comments mainly related to the organisation, with Group 1 students indicating the lecture was not needed. Both groups wanted better prizes, with Group 2 indicating they wanted more sessions of the same nature.

**Conclusions:** A bingo-TBL session is equivalent to a standard lecture in short-term knowledge improvement, a finding supported by research which has identified exam scores for TBL are comparable to traditional teaching methodologies [1]. The students reported a more positive experience associated with the bingo-TBL. As such, this pedagogic technique is recommended in place of standard lectures in order to not only diversify the curriculum to cater for all learners, but to also get students more engaged with the topic in a fun, team-based, learning activity.

**Implications for practice:** Bingo-TBL can be used to improve student engagement and enjoyment, with increased team-working within the cohort, without compromising knowledge attainment.

Keywords: Team-based learning, bingo, flipped classroom, pedagogy, interactive.

# INTRODUCTION

A teaching innovation, utilising bingo team-based learning (TBL), was introduced for an undergraduate [Year 1 (Level 4)] module for the Diagnostic Radiography BSc (Hons) programme at an institution of Higher Education in the United Kingdom (Module code IMAG134: Foundations of Radiography and Radiographic Practice of the Chest and Abdomen). This was delivered twice: the innovation was first piloted, and then a more robust evaluation undertaken, as detailed below. The rationale for the change came from module team and external examiners who noted that students performed poorly on an exam question in which they had to provide definitions for common terminology used in radiology.

* + 1. *Team-Based Learning (TBL): The Flipped Classroom*

In a systematic review of active learning techniques amongst health care students [2], 72% of the of studies on lower-order cognition indicated active learning techniques were effective at achieving improved recall, understanding, and/or application of course material. In addition 84% of the studies on higher-order cognition supported active learning over passive instruction for improving students’ confidence in or performance of analytical, evaluative and creative skills. The flipped classroom [3] involves a reversal of traditional teaching where students gain exposure to new materials outside of the classroom, usually through reading or lecture videos, with the class time then used for the harder work of assimilating that knowledge through strategies such as problem-solving, discussion or debates.

* + 1. *Gamification: Utilisation of the Game ‘Bingo’*

Gamification has been identified [4] as the utilisation of game-like design elements in a non-game context to motivate people to solve problems; this may involve points, badges, leader boards etc. which can be used to trigger particular behaviours among users and respond to their psychological needs. Gamification has been demonstrated to be an effective teaching strategy for nursing students [5], with research identifying students can develop deeper learning of the content. In addition, Stress levels are subdued, critical thinking is promoted, nursing students become motivated, and enjoy participation in a nonthreatening environment.

The game ‘bingo’ has previously been used in a number of higher educational contexts to induce active learning. One study reports a bingo game for the topic ‘sociological approaches to the study of the body’ [6]. However, the traditional game of bingo whereby numbers are crossed off a bingo card with the first to mark all numbers calling ‘house’ was modified with the authors describing their game as a cross between the game of bingo and a traditional class survey. A modified bingo game was utilised to teach Kenneth Burke’s theory of dramatism [7], with a 4x4 bingo card containing randomised definitions of key terms from the assigned reading placed in each box. The instructor reads out the terms from the reading with students marking off the definition on the card, winning extra credit for completing a line/full card. Whilst students were allowed to confer, no teams were assigned. In addition, the definition for each term was contained on each card, which introduced an element of guesswork. The game bingo has also been used to help consolidate teaching of chemical nomenclature [8]; the author describes the teaching and drilling of this subject as ‘particularly mind-numbing’. Chemical name fragments are marked off a 5x5 grid on a bingo card as chemical symbols are projected on the screen for the students to view. The first student to mark off a row of 5 wins, with the spaces double-checked against the proper name. At the end of each round the correct names are uncovered and discussed. In an accounting course [9] bingo was used to generate interactive teaching of ethical principles, with a 5x5 bingo card containing ethical categories which the students identify on PowerPoint slides containing timely examples of practices reported in the press. Prior to the bingo session the students engage in a discussion on ethics. Whilst students mark off the principles on their bingo card, they have to defend their decision, thereby generating discussion. The students submit a ‘winning card’ to the instructor who uses the class notes to check off the terms. Further research [10] modified the format, with the terms within the matrix replaced by numbers, and when the number was drawn as a brief fact about ethics or independence was read out. It was only once the students had completed five spaces they entered the final round of the game where they undertook a number of jeopardy-style questions which correspond with the students’ winning board numbers, the successful answering of which earn the winning groups of students bonus points which can be used to improve low grades.

# METHODOLOGY

### Pilot study

For the pilot study the Year 1 cohort were provided with two lists, one of common medical terms and one of common cardiorespiratory pathologies, and instructed to complete a workbook containing the definitions in directed private study time ahead of a teaching session. During the teaching session the students (n=56) were divided into teams of four. Each team was given a bingo card, but rather than numbers the boxes on the bingo cards contained words from the lists in the workbook; each list formed the basis of a game of bingo.

A bingo machine was used to draw balls in a random order, with the number corresponding to one of the terms on the list; the corresponding definition relating to the term was read out, and students were given time to identify whether they had the matching term on their bingo card, discussing the definition amongst their groups. In keeping with the rules of bingo, once a group had marked off a full row of terms, they shouted ‘house’ or something similar, and their card was checked. When the card was full, they again shouted ‘house’ and the card was checked again, until there was a confirmed winner. Each row and full house won the team prizes (chocolates) as an extrinsic motivator. For each list of the word lists, two games of bingo were played, resulting in four games of bingo in total.

Following the bingo session, a short survey (6 Likert items and 2 open questions) was disseminated amongst the cohort in order to perform an evaluation of the teaching technique. 47/56 responses were received (83.9% response rate). Results demonstrated 77% of students agreed and 19% strongly agreed that the session helped consolidate their knowledge of the terminology, with 53% agreeing that they remembered more terminology than they expected, which was a particularly useful finding as the students had not been made aware that the bingo session would effectively be a ‘test’ of their knowledge of the terminology. The students overwhelmingly agreed (94%) that they enjoyed being able to discuss the definitions in a group, with only 2% not wanting another bingo session; the students also overwhelmingly agreed (94%) that they would like more interactive teaching methods similar to terminology bingo.

The open responses identified some issues with the bingo session, grouped into three themes:

1) Words: lists were too long with ambiguity in the terms;

2) The environment: noise in the room and layout in a traditional lecture layout was not satisfactory;

3) Organization: related to the way the session was run, including the time for discussion and clarification of definitions after each row/house.

Based on the findings of the pilot evaluation, a presentation on this emerging idea was given to a Pedagogic Research Conference and attendees’ opinions were combined with the students’ feedback to refine the innovation and produce a protocol to undertake a more robust evaluation of the innovation. The full evaluation of the bingo-TBL is detailed below.

### Ethical Approval

Following submission of a study protocol, participant information sheet, consent form and invitation e-mail, ethical approval for the evaluation was granted by the Health and Life Sciences Research Ethics Committee (approval number: 4960) and the bingo session was run again in semester 2. Prior to their Easter vacation, the students were informed that they would be undertaking another bingo-TBL session. The participant information sheet was attached to an invitation e-mail which was sent to the entire first year cohort ahead of the planned data collection, shortly after the Easter vacation. Upon attending the students were informed that the teaching activities were not optional, as they were timetabled for the module, but that their participation in the research project was entirely voluntary and should they wish to participate they could withdraw at any time. A paper copy of the participant information sheet was distributed to each student. Students were then provided with consent forms and advised to raise any queries they had at that point. Fully informed consent was obtained prior to starting data collection.

### Teaching Material: Abdominal Pathology Workbook

Students were asked to complete a PowerPoint based workbook on common abdomen pathologies prior to the bingo session, during their Easter vacation time. The topics covered in the workbook related to pathologies which were appropriate for the level of study (Level 4). The workbook contained 22 images of radiographs which related to the relevant pathology, with each slide containing information pertaining to the image, with several blanks. Unique resource locators (URLs) were provided for web-sites which contained the source information for the workbook, and from which the missing information could be gleaned by the students. The students were provided with a completed version of the workbook the evening before the teaching sessions.

### Study Protocol and the Bingo Game

This study was planned with a cross-over methodology whereby half the cohort were randomised to two Groups. The order in which the teaching activities were delivered was different for each group. Group 1 attended for a morning teaching session, and received the bingo-TBL activity first followed by a standard lecture which went through the workbook to fill in the blanks. Group 2 attended for an afternoon teaching session, and received the standard lecture first followed by the bingo-TBL activity. A pre- and post-test quiz (consisting of 20-questions administered via the app ‘Socrative’ ([www.socrative.com](http://www.socrative.com)) was administered to both groups, before and after the first teaching activity. After the second teaching activity students were asked to provide both positive and negative comments relating to the overall session on post-it notes. Figure 1 illustrates the study protocol.



Figure 1. Study protocol for Bingo-TBL evaluation project.

The bingo-TBL consisted of two games of bingo. The students were randomly allocated into groups of 3 or 4, depending on the numbers attending each session. For each game, each bingo team was given a bingo card which consisted of a grid of 4x5 words, with one blank space on each of the rows, so although there were 5 boxes per row, there were only four containing a term or medical condition which related to the PowerPoint on common abdomen pathologies that the students had completed prior to the session. An Excel macro was created to generate the bingo cards, which contained random selections of 16 words from the 36 possible. During the game, a number was drawn from a bingo machine, and the word on the master list of 36 corresponding to this term was identified, and the definition for the word/medical term read out by the bingo caller (one of the study authors). Once a team completed a row they shouted ‘house’ to indicate as such, and the bingo caller would check, with the help of one of the co-authors, that they had indeed completed a row of correct words/terms. If all of the words/terms marked on that row of the bingo card were correct, the definitions were re-read, and the correct words/terms were identified, to ensure none of the teams were left behind. This continued for further rows, and then for a full house. After each successful row a mini-chocolate bar was given to each of the team members, with a larger packet of sweets awarded for the ‘full house’.

The standard lecture was delivered in a didactic way, and the blanks in the PowerPoint which had been provided to the student were filled in as the lecture proceeded. The lecture was recorded and made available to the students through their virtual learning environment (Blackboard).

### Quantitative Analysis

The test scores for the pre- and post-test quiz for Group 1 and Group 2 were transferred from the Socrative app into Microsoft Excel to facilitate descriptive statistical analysis. The scores were then grouped and transferred into the statistical analysis software Statistical Product and Service Solutions (SPSS) Version 26 in order to undertake inferential statistical analysis. The scores for each group were first subject to analysis to determine whether the data was normally distributed, with utilisation of the Kolmogorov-Smirnov test and inspection of the histogram distributions for each data-set in order to determine if a transformation of the data could be facilitated if necessary. For normally distributed data, the paired t-test was appropriate; for non-normally distributed, non-transformable data, the Mann-Whitney U test was appropriate. Statistical significance was seen where p-values were less than 0.05.

### Qualitative Analysis

The responses collected on the post-it notes generated qualitative data, which was examined using thematic analysis. The method was similar to that employed in an Australian study [11], whereby a ‘nominal method of quantitative transformation’ was applied; key words and phrases were identified to indicate their perceived importance to participants, with the most frequently recurring terms subsequently grouped by meaning to enable thematic analysis.

# RESULTS

## Quantitative Analysis

Inspection of the frequency histograms pre- and post-test data for both Group 1 (am) and Group (pm) revealed that the distributions were normally distributed, which was subsequently confirmed by the Kolmogorov-Smirnov test for normality. Subsequently, the paired t-test was used to compare the means of each group, with statistical significance seen where p<0.05.

As demonstrated in Figure 1, the mean test score improved for both Groups. For Group 1, which received the bingo-TBL session followed by a standard lecture, the quiz scores (mean ± s.d) were 12.11 (± 3.64) for the pre-test quiz and 16.56 (± 3.78) for the post-test quiz; the increase in means was statistically significant (p<0.001).

For Group 2, which received the standard lecture followed by the TBL-Bingo session, the score for the pre-test quiz (13.38 ± 4.20) was slightly higher than for Group 1, with the score for the post-test quiz slightly lower (16.29 ±2.69) than Group 1; the increase in mean seen for Group 2 from the pre- to post-test quiz was statistically significant (p=<0.001).

Whilst slight differences in the pre- and post-test means are noted between the groups, neither the difference in the pre-test means nor the difference in the post-test means were statistically significant (p=0.281 and p=0.428 respectively).



Figure 2. Comparison of test scores for Group 1 (AM) and Group 2 (PM)

## Qualitative Analysis

### Positive Comments

Table 1. Positive Comments.

|  |  |  |  |
| --- | --- | --- | --- |
| Theme | Group 1 | Group 2 | Total |
| Organisation | 35 | 18 | 53 |
| Method | 16 | 22 | 38 |
| Experience | 14 | 20 | 34 |
| Competition | 3 | 1 | 4 |
| Total | 68 | 61 | 129 |

As demonstrated in Table 1 there were a total of 129 positive comments. The main positive theme overall related to the organisation of the teaching activities, with more comments from Group 1. One of the main sub-themes under organisation was the size of the room, groups and sub-groups used for the session, often with comparison to the pilot study. Positive comments included “…I liked how we were in smaller groups so you could contribute and learn the content…”, “…learnt much more by working as a smaller group than last time…” and “…split into two groups am/pm so easier to hear what was going on…”. Students also liked going through the definitions in stages throughout the bingo so they could be sure they had the correct answer, which again was an acknowledged improvement over the pilot, with comments such as “…I liked how we were told the correct answers after so make you aware if you got it right or not…” and “…correct definitions read out clearly, made definitions easier to learn…”.

The second most frequent theme in the positive comments related to the method of teaching delivery, with several students commenting “…being tested was good…”, “…tests your knowledge…” and “…very informative and felt like I actually learn a lot and it helped a lot with my revision…”. Other students liked the inclusion of prizes and an opportunity to be tested, commenting that the session provided “…valuable feedback…” and they “…enjoyed seeing my improvement on the second quiz…”. Students also compared the session to a standard lecture, commenting that “…the bingo was more exciting and fun than a conventional lecture…”.

In relation to the theme of ‘experience’, the students found the TBL-Bingo methodology fun, interactive, enjoyable, and very engaging with comments such as “…would like this for other modules…” and “…fun and engaging…”. In addition, the students in Group 2 also liked having a lecture prior to the bingo-TBL, as this helped consolidate their learning.

In the final positive theme of ‘competition’ there were several specific comments on how the students valued the competitive element of bingo-TBL, with one commenting “…competitive so encouraged to do the revision…”.

### Negative Comments

As demonstrated in Table 2 there were a total of 34 negative comments.

Table 2. Negative Comments.

|  |  |  |  |
| --- | --- | --- | --- |
| Theme | Group 1 | Group 2 | Total |
| Organisation/delivery | 9 | 12 | 21 |
| Positive comment | 4 | 4 | 8 |
| Summary of definitions | 3 | 2 | 5 |
| Total | 16 | 18 | 34 |

The main negative theme related to organisational and delivery aspects, with several comments indicating that the students thought the lecture at the end of the morning session was unnecessary “…didn't feel the need to have the lecture at the end as I felt I learnt more in the bingo and quiz…”. Some students wanted a reduction in the time for the whole session, with suggestions that the second round of bingo and the break were also unnecessary. In addition some students wanted better prizes, and some background music/sound effects.

The second most common theme was actually positive comments, with some students indicating “…nothing negative…” and “…much better than first session! Thank you!!!” Other comments indicated that the students thought the teaching could be transferred to other areas, such as “…more sessions like this - maybe on anatomy…” and “…we should do more lectures like this as it is really good for learning…”, noticeably from Group 2.

The final negative theme was the idea that the students wanted a summary of the definitions, with comments such as “…full list of terms would be useful…” and “…would be good to have a sheet of definitions of pathology beforehand to summarise the PowerPoint content….”

# CONCLUSIONS

The results demonstrate that both the standard lecture and bingo-TBL resulted in an equivalent uplift in test scores after the first teaching intervention, which indicates that bingo-TBL session is equivalent to a standard lecture in short-term knowledge improvement. These findings echo those of another project [1] which found exam scores on the question which related to TBL-taught material were comparable to the lecture-taught material. In contrast, a further study [12] found nursing students’ exam scores were significantly higher for a flipped classroom group compared to both lecture only, and lecture plus lecture capture groups, whilst another study [13] demonstrated significant improvements in three tests during a pharmacology unit in an undergraduate nursing degree course, but no significant difference in the final exam. The long-term effects in another study [14] were similar to the short-term improvement seen here. The authors found no statistically significant difference in outcomes between nursing students randomised to a flipped-classroom teaching methodology or traditional classroom teaching.

Focussing on other academic skills, a further study [15] found a statistically significant improvement in problem-solving ability and learning satisfaction amongst undergraduate students exposed to a ‘blended’ teaching intervention compared to a more traditional classroom setting. In addition to these traditional means of measuring student attainment, the authors of another study [16] also note that TBL may help improve clinical decision making or scores in clinical practice exams. Whilst the students in the bingo-TBL study presented here were not being tested on their practical skills, given the literature supports the findings here that TBL leads to at least equivalence in academic attainment suggests, we can conclude it was an appropriate alternative to traditional teaching for the abdominal pathology. Further research into bingo-TBL should also focus on the longer-term attainment of students, with possible retesting at later points in the semester, or the inclusion of summative assessment results in future studies.

In other reported studies no quantitative comparison of the bingo-based teaching intervention with a control group has been undertaken. However, an informal poll [8] of students indicated that it was a productive use of class time and provided good reinforcement of the topic, providing a nonthreatening opportunity for feedback to the instructor on the students’ weaker areas. The author also indicates that the primary complaint from some students was the trade-off of class time to play the game against using that time for lecturing on nomenclature rules. The authors in another study [9] did undertake a short survey, and a number of themes emerged. First, the students provided positive comments to the game itself, indicating it was fun and interactive. The authors report that the students were ‘very taken by the game’ and actively participated, providing uniformly positive feedback and that more reticent students were encouraged to participate. These findings reflect the positive comments of the students in the present study, which found bingo-TBL can be used to improve student engagement and enjoyment, with increased team-working within the cohort, without compromising knowledge attainment.

Other research investigating the student perceptions of TBL has reported similar positive findings. One study [1] found that most students (76%) reported a preference for TBL, with 21% reporting a preference for traditional lectures. TBL overall was seen as a very good alternative to lectures, with TBL providing a ‘novelty factor’ as an alternative to traditional lectures. Accountability was also higher with TBL, with preparing in advance to be able to contribute meaningfully was seen as acting fairly towards the group, and also as an opportunity to take full advantage of the TBL activities. Further research [7] has also identified that utilising bingo in the TBL context is advantageous as it affords students the opportunity to work together and also correct each other’s misunderstandings, fostering peer-to-peer feedback. A systematic review [16] of the evidence for TBL in nursery and midwifery higher education found there is a tentative, though growing, body of evidence to support TBL as a strategy that can impact on student engagement and student satisfaction, in addition to student attainment. The review [16] further noted that implementing TBL within the curriculum is not without challenge, requiring a sustained and structured approach. Further research [17] has found in the setting of undergraduate medical students, three weeks of TBL did not lead to a reduction in in-class time, and students did not report overload in study hours or in cognitive load. Given the Year 1 diagnostic radiography cohort in the bingo-TBL study presented here had already been exposed to a flipped-classroom TBL format for their anatomy teaching, this helped facilitate an easy transition to the gamified TBL approach utilising ‘bingo’.

The students reported a more positive experience associated with the bingo-TBL. As such, this pedagogic technique is recommended in place of standard lectures in order to not only diversify the curriculum to cater for all learners, but to also get students more engaged with the topic in a fun, team-based, learning activity. As learners return to face-to-face classroom teaching in a post-pandemic setting, collaborative TBL activities such as the one presented here will help reintegrate student cohorts.

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