Evaluating the effectiveness of a board game to learn biological psychology facts

Emma Whitt & Mark Haselgrove

Using games in a classroom setting to help engagement and learning is becoming popular, but controlled investigations into the benefits of games are few. Games are potentially a way to incorporate retrieval practice into a class and garner subsequent benefits to memory. The aim of the present study was to investigate whether a board game assisted students to remember facts from a year one biological psychology module. Forty-seven participants (42 female, 5 male) took part in a seminar to test the hypothesis that playing the board game would enhance memory compared to taking part in a quiz. An experimental design was adopted with a between-subject factor (group: board game versus quiz) and two within-subjects factors: time of test (before the seminar, immediately after the seminar, 7-days after the seminar) and question type (seminar questions, i.e. questions contained in the game or quiz versus control lecture questions, i.e. questions that were not contained in the game or quiz but in a lecture). Contrary to the hypothesis, there were no differences in scores between the board game and quiz groups. We propose this is due to both groups having participated in retrieval practice during the game or the quiz. However, there was a significant main effect of time of test (scores immediately after the seminar increased) and a main effect of question type (scores were higher for seminar questions than control questions). The time of test x question type interaction was significant; post hoc analyses show that both groups scored higher on seminar questions compared to the control lecture questions in the after seminar test, and in the 7 days test. In conclusion, games can engage students and help them to remember complex material, but it is the use of retrieval practice specifically that aids memory. Our data show that retrieval practice can be equally effective in a board game or quiz, but students preferred the board game.

Keywords: *Active learning; Game-based learning; Biological psychology; Retrieval practice.*

WHILE STUDYING any course, students need a certain level of knowledge about their subject to enable them to find connections between facts and concepts and transfer understanding to new domains (Biggs & Collis, 1982). As such, teaching in a first-year course in higher education may focus on teaching and learning of core facts (e.g. names and functions). This is certainly the case in biological psychology, a core component of most psychology courses (QAA, 2019), and a subject that is difficult and requires extra effort from instructors (Peck et al., 2006).

Using active learning in higher education is encouraged (National Committee of Inquiry into Higher Education, 1997; Mortiboys, 2010) and includes tasks that 'involve students in doing things and thinking about the things they are doing' (Bonwell & Eison, 1991, p. iii). Active learning promotes an environment of student involvement rather than passive listening, and student participation is key (Børte et al., 2020). A variety of different approaches to active learning can be used, including flipped classrooms, blended learning, classroom discussions, and peer-to-peer learning. Active learning is popular in higher education and evidence shows that using it increases performance in examinations in science, technology, engineering, and mathematics subjects across all class sizes, but is particularly effective for smaller classes (Freeman et al., 2014).

Game-based active learning has been shown to improve learning, and involve and engage learners (Garris et al., 2002). Meta-analyses report the positive effects of game-based learning generally (e.g. Karakoç et al., 2022) and more specifically in science

DOI: 10.53841/bpspsr.2023.29.1.13

subjects (e.g. Hu et al., 2022; Lei et al., 2022; Riopel et al., 2019). Positive effects relate to higher achievement (Karakoç et al., 2022; Lei et al., 2022) cognition and motivation (Hu et al., 2022), and declarative knowledge and retention (Riopel et al., 2019) compared to standard instruction. Even gamification – where aspects of games are incorporated into education – has been shown to have positive effects on cognition and motivation (Sailer & Homner, 2020). There is, therefore, emerging evidence to suggest that using games improves learning and motivation.

Using games in class allows learners to make errors within the context of a fun environment (Whitton & Moseley, 2012), and games have been introduced as a method of learning in psychology courses in several ways. For example, Abramson et al. (2009) reported types of games (including Pictionary, Scattergories, Taboo, and Wheel of Fortune) that can be adapted to teaching the history of psychology. Trivial Pursuit has been adapted in a counselling course to help students to study for a final exam on introductory counselling (Robison, 2014), a version of Cranium during a general psychology course to help students in a general psychology course (Goldey & Espinosa, 2020), and a citation game improved understanding of APA formatting (Clark & Murphy, 2021). Furthermore, various games, including a version of Monopoly, have been used to teach psychopharmacology (Scarlet & Ampolos, 2013). In all these evaluations, students were positive about the game. However, researchers do not always directly measure learning of the content of the game, but instead ask students if they thought the games helped their learning (Abramson et al., 2009; Scarlet & Ampolos, 2013). Other researchers only report exam performance (Goldey & Espinosa, 2020; Robison, 2014), which is problematic because exam performance may be subject to other contributing factors and not just the classroom intervention (such as, for example, personality and goal-specific cognitions [Phillips et al., 2003], test length [Ackerman & Kanfer, 2009], and attendance at classes [Marburger, 2001]).

Among several learning techniques that have been shown to be successful is retrieval practice (see Dunlosky et al., 2013). Retrieval practice is a method in which learners are asked to answer questions from memory, and it has been shown to result in better memory for content, particularly after using a practice test – a phenomenon known as the testing effect (Roediger & Karpicke, 2006). A meta-analysis that included 272 effect sizes from studies involving 15,427 participants showed the robust nature of the testing effect (Adesope et al., 2017). The effect replicates across different test formats (e.g. cued-recall, free-recall, multiple choice questions) and practice testing only needs to be used once before the final test to be effective. This meta-analysis also shows that the effect is present with different retention intervals, but intervals of 1-6 days result in a bigger effect size than intervals of 1 day. Games that incorporate retrieval practice are therefore likely to help students to remember material. Although there is a consensus that students enjoy games as part of the course, and that they can increase students' preparation (Scarlet & Ampolos, 2013), Goldey and Espinosa (2020) show that effects on learning are generally similar to other methods of learning or instruction, such as question and answer sessions. This is likely because these methods incorporate retrieval practice. Games could be used by instructors to vary the learning activities used in the classroom, therefore investigating the efficacy of games is important to ensure they are at least as effective as a simple question and answer session; but there are limitations when investigating game use as educators. Most notably, these include the lack of a control group (Clark & Murphy, 2021; Scarlet & Ampolos, 2013), and the lack of investigation into the effect of retention intervals (Goldey & Espinosa, 2020). In the present study, we used an experimental design to incorporate comparison factors of question type (questions that were used

in the seminar or not), time of test (before the seminar, immediately after the seminar and a week later) and a control group (i.e. a group that does not play the board game) to address some of these issues.

Here, a seminar was designed to compare memory and student engagement following a board game or a simple quiz. A seminar was used primarily for practical reasons as the number of game boards was limited, but also active learning is particularly effective in small classes (Freeman et al., 2014). The research questions were:

- Is there a difference in memory for facts between the board game and quiz conditions?
- Are learning benefits of participating in a seminar longer-term (a week after the seminar)?
- What are student and staff perceptions of the two types of games used in the seminar?

It was hypothesised that the board game would enhance learning relative to the quiz, that this enhancement would persist after a week. We also expected that students would enjoy the board game more than the quiz.

Method

Participants

Forty-seven students participated with a mean of 5.9 (*SD* = 1.25) students per seminar. Participants were aged 18-25 years (*M* = 19.04, *SD* = 1.30). One participant did not report their age. Forty-two participants identified as female, and five identified as male, which is representative of the cohort at our institution. In the board game group, there were 23 participants (20 female, 3 male; *M* age = 19.0 years, *SD* = 0.83). In the quiz group there were 24 participants (22 female, 2 male; *M* age = 19.1 years, *SD* = 1.66). All participants were enrolled on the first year of an undergraduate psychology degree at a UK university and were studying a biological psychology module at the time they participated in the present study. Procedures were approved by the departmental ethics committee and participant consent was obtained before each test.

Eight seminars took place, each led by one of five members of staff. Six of the seminars were compulsory sessions that students attended as part of their course and two seminars were sessions that students opted to attend. There was no difference between the memory scores for these two seminar types, therefore these seminar types were collapsed for further analyses.

Design

A 2 x 3 x 2 mixed design was used with a between-subjects factor of group (board game or quiz) and a within-subject factor of time of test (before the seminar, immediately after the seminar, and 7-days after the seminar). The final factor was question type used during the tests. Two question types were used that tested knowledge for facts about biological psychology: (1) questions from the question cards used in the seminar (seminar questions) and (2) control questions from a lecture that were not used in the seminar (control lecture questions); this was incorporated as a within-subject factor (see Appendix for questions).

Materials

Board Game

The game was 'take the neuro highway' created by Colette Beecher (Sheffield Hallam University, 2016), a board game in which the board comprises a labelled picture of a sagittal midline view of the brain; the aim is for players to follow the path of sensory-motor messages through the brain. On their turn, players use a six-sided die to determine how many steps they can move, and at points in the path they reach a barrier and must answer a question to continue. Questions were written on brain-shaped cards (one question per card) and players were required to answer the question from the card at the top of the stack. Used cards were returned to the bottom of the

stack. The game contains 78 question cards but, for the present study, 33 question cards were chosen that matched the content of the first-year biological psychology course. Shuffled among the chosen question cards were eight 'mishap' or forfeit cards that sent players back either a few steps or to the beginning of the board. An example of a mishap card is 'Too much caffeine – you cannot sleep – move back four places'. This game was used as it is the only example of a board game that we are aware of that has content related to biological psychology.

Before-seminar test

A test was used to measure all participants' knowledge. This was presented via Qualtrics, which participants completed on their own devices. Qualtrics permitted the collection of anonymous responses to questions and optimises presentation of the questions on mobile devices. The before-seminar test contained six questions about biological psychology factual knowledge. Four questions were from the question cards that were used in the seminar (seminar questions) and two questions were from a lecture given a few weeks earlier (lecture questions; see Appendix). In this way, seminar questions were presented four times to participants: Before the seminar, during the seminar (as part of the game), after the seminar and after 7 days. Lecture questions were also presented four times to participants, however these occurred during the aforementioned lecture, before the seminar, after the seminar and after 7 days. All test questions were of a similar difficulty; that is, they were all based on facts that were presented in the module content. All questions were multiple-choice with one correct answer and three distractors. Participants were told to guess if they did not know the answer. The test took about 5 minutes and there was no feedback. Participants were also asked to enter information about which seminar group they were in and their age and gender.

After-seminar test

The after-seminar test (completed immediately after the seminar) was identical to the before-seminar test, but also included questions that asked participants to rate on a 1-7 scale (where 1 represents 'not' and 7 represents 'very') (a) their confidence in their knowledge of biological psychology, (b) their enjoyment of the seminar and (c) the difficulty of the seminar. They were also asked if they would recommend the seminar to other students. All participants were asked to complete this test at the end of the seminar.

7-day after-seminar test

This test was identical to the before-seminar test. All participants were invited to complete this after a seven-day retention interval.

Staff survey

A questionnaire was sent to staff who led the seminars. This comprised four questions and asked staff to rate their answer on a 1-7 scale. (Q1) Do you think that the seminar leader preparation that was involved for this seminar was...? Too much (1) About right (4) Too little (7). (Q2) How engaged with the material were the students during this seminar? Not at all (1) to Very much (7). (Q3) Would you recommend this seminar to colleagues? Not at all (1) to Very much (7). (Q4) How would you rate the difficulty of the material in this seminar? Too easy (1) to Too hard (7) and a free-text box to provide any comments about how the seminar went.

Procedure

Two tasks were constructed that formed the two groups: board game and a quiz. The task took place in a face-to-face seminar, which lasted for 60 minutes. Which group students were allocated to depended on their seminar group; staff were randomly allocated to the game or quiz group. Seminars were conducted on different days across a semester and at different times of day. Start times of the seminars were between 10am and 2pm. In the first 5-10 mins of the seminar, students were welcomed and asked

to complete the before-seminar test on their own device. After this, the seminar leader told the students what the task was. The task took 45-50 mins and students completed the after-seminar test in the last 5 mins of the session.

In the board game group, the game was played by the whole group, but students were told to form pairs or groups of three so they could answer questions together. Students were encouraged to discuss answers together in their pair/group before deciding on their final answer. Students in an opposing team read out questions to the team who had reached a barrier. The seminar leader confirmed if the answer to the question was correct.

In the quiz group, students did not use the game board but took turns to answer the questions on the cards. They again worked in pairs or groups of three and read out questions to each other. They did not use the die to instruct their movement around the board or encounter any mishap cards. However, it was necessary to ensure the participants had the board in view during the seminar because the image on the board was labelled, and so contained names of brain areas that could have been used to answer some of the questions, therefore it was pinned to the wall.

At the end of the seminar, students were asked to complete the after-seminar test and were told that they would receive an email in seven days asking them to complete the follow-up test. All tests were anonymous, and responses were linked via an ID code that participants created themselves. Follow-up tests were completed on average 7.48 (*SD* = 0.92) days after the seminar. Staff were asked to complete the staff survey after the seminar.

Results

Data from all participants were included in the analysis; data from all 47 participants was acquired from the before seminar test, data from 43 participants from the immediately post-seminar test, and data from 23 participants from the 7-day test. The proportion of correct responses was calculated for each participant for each of the three tests. As seen in Figure 1, before the seminar, groups performed similarly on the questions, performing at approximately chance level (0.25). Immediately after the seminar, and at 7 days, however, both the board game group and the quiz group performed better on the seminar questions relative to the control lecture questions. This impression was supported by a mixed 2 x 3 x 2 analysis of variance (ANOVA) with a between-groups factor of group (board game or quiz) and within-subject factors of time of test (before the seminar, immediately after the seminar, and 7-days after the seminar) and question type (seminar questions or control lecture questions). The assumption of sphericity was not violated for time of test or its interaction with question type, Mauchly's Ws > 0.837, *p*s > .16. This means no correction was applied.

There was no significant effect of group (board game vs quiz), $F(1,21) = 0.99$, $p = .332$, $\eta^2_p = 0.045$ (Board game $M = 0.45$, $SE = 0.05$, 95 per cent CI [0.36, 0.54; Quiz $M = 0.51$, $SE = 0.05$, CI [0.42, 0.61).

There was a significant main effect of question type, $F(1,21) = 38.39$, $p < .001$, $\eta^2_p = 0.646$, with participants getting more correct answers to seminar questions ($M = 0.65$, $SE = 0.04$, 95 per cent CI [0.56, 0.73]) compared to the control lecture questions ($M = 0.31$, $SE = 0.04$, 95 per cent CI [0.23, 0.40]). There was also a main effect of time of test, $F(2, 42) = 14.14$, $p < .001$, $\eta^2_p = 0.402$. Tukey post-hoc tests show that scores before the seminar ($M = 0.35$, $SE = 0.04$, 95 per cent CI [0.26, 0.43]) were lower than immediately after the seminar ($M = 0.62$, $SE = 0.04$, 95 per cent CI [0.53, 0.72]), $p < .001$. Scores at 7 days ($M = 0.47$, $SE = 0.04$, 95 per cent CI [0.38, 0.56]) were lower than after the seminar, $p = .014$, but there was no difference in scores before the seminar and 7 days, $p = .059$.

There was a significant interaction between question type and time of test, $F(2, 42) = 8.66$, $p < .001$, $\eta^2_p = 0.292$. Tukey post-hoc tests show that before the seminar, there was no difference in scores between the

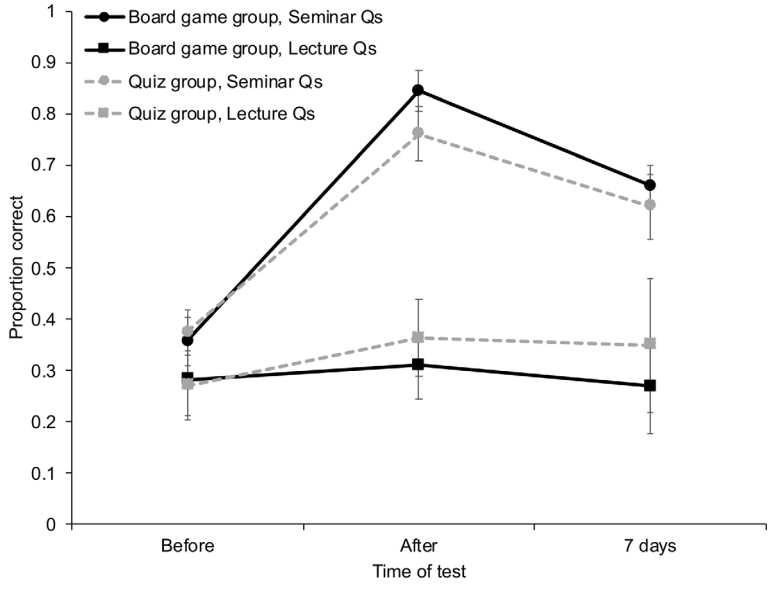
question types, $p = .057$. Immediately after the seminar, and at 7 days there was a difference, $ps < .001$, with more seminar questions answered correctly compared to control lecture questions. Looking at post-hoc tests for the seminar questions alone, there was a difference in scores before compared to after the seminar, $p < .001$, and before compared to 7 days, $p = .031$, in both cases the score before the seminar was lower than the comparison. There was also a difference in scores after the seminar compared to 7 days, where scores were lower in the 7 days test, $p = .007$. There were no differences in any of the same comparisons for the scores for the control lecture questions, $ps > .90$. All remaining interactions were not significant, $Fs < 1$.

Student experiences of the seminar

Even though there were no differences in the memory-test data for game type, the groups may have responded differently to the seminar because of their different experiences. Table 1 shows how students responded to the experience questions. Participants in the board game condition gave higher enjoyment ratings than participants in the quiz condition, $t(39) = 3.14$, $p = .003$, $d = 0.981$, 95 per cent CI [0.29, 1.65]. However, the groups were similar in their rating of their confidence in their knowledge of biological psychology, $t(39) = 1.10$, $p = .278$, $d = 0.344$, 95 per cent CI [-0.28, 0.96], and in rating the difficulty of the seminar, $t < 1$.

Students were asked if they would recommend the seminar to other students on a 1-4 scale (1 = definitely yes, 2 = probably yes, 3 = probably not, 4 = definitely not). Students in both groups on average agreed that they would recommend the seminar to other students ($M = 1.24$, $SD = 0.44$ in the board game group, and $M = 1.60$, $SD = 0.60$ in the quiz group) but with the quiz group giving a less firm recommendation, $t(39) = -2.22$, $p = .032$, $d = 0.694$, 95 per cent CI [-1.34, -0.038].

Figure 1: Mean Proportion Correct in Each Test by Condition (Board Game vs Quiz), Time (Before Seminar, After Seminar, 7 Days After Seminar) and Question Type (Seminar vs Lecture)



Note. Error bars represent one standard error of the mean.

Table 1: Means and Standard Deviations of Student Perceptions of the Seminar

	Game *M (SD)*	Quiz *M (SD)*
Rate your confidence in your knowledge of biological psychology	3.33 (1.07)	3.00 (0.86)
Rate your enjoyment of the seminar	6.14 (0.85) *	5.30 (0.87) *
Rate the difficulty of the seminar	4.67 (1.07)	4.54 (0.75)

Note. Ratings were given on a 1-7 scale where 1 = 'not' and 7 = 'very'. Game $n = 21$, quiz $n = 20$. * $p < .01$

Table 2: Means and Standard Deviations of Staff Perceptions of the Seminar

	M	*SD*
Do you think that the seminar leader preparation that was involved for this seminar was...? Too much (1) About right (4) Too little(7)	4.25	0.50
How engaged with the material were the students during this seminar? Not at all (1) to Very much (7)	5.75	1.89
Would you recommend this seminar to colleagues? Not at all (1) to Very much (7)	6.00	1.41
How would you rate the difficulty of the material in this seminar? Too easy (1) to Too hard (7)	4.25	0.50

Note. n of responses = 4

Staff experiences of the seminars

The results from the staff questionnaire can be seen in Table 2. Three staff (out of five) completed the questionnaire; one of those staff conducted both the game and quiz seminar and so provided two responses. Generally, staff thought the preparation time was about right, that the students were engaged in the seminar. Staff would also recommend the seminar to colleagues and they judged that the difficulty of the seminar was about right.

Discussion

The aim of the present study was to investigate the efficacy of a board game on learning biological psychology facts. The results indicated that both the board game and quiz seminar improved students' knowledge of biological psychology facts contained in the seminar relative to those facts that were not (control lecture questions). This difference lasted over a retention interval of one week. In addition, students enjoyed the board game more than the quiz and staff perceived that both types of games were engaging for students.

Finding no difference between the board game and quiz groups contradicted our hypothesis that the board game would enhance memory to a greater extent than the quiz. One explanation for this is that the board game features did not add benefits to learning beyond the retrieval practice afforded to both groups (board game and quiz). This was perhaps not surprising given the robust nature of the effect of retrieval practice on memory recall (Adesope et al., 2017). Owing to the limited scale of this study, we were not able to include an additional control group that *did not* receive a retrieval-practice based seminar. Finding

poorer memory performance in such a control group would have added support to the hypothesis that retrieval practice was the mechanism by which the board game and quiz conditions enhanced memory recall.

All students enjoyed the seminar, with participants in the board game group giving higher ratings than participants in the quiz group. Student enjoyment and satisfaction with games is also present in past research (Goldey & Espinosa, 2020; Robison, 2014; Scarlet & Ampolos, 2013), suggesting they are a good tool to engage students with material and learning. The present study also explored staff experience, something that has not been reported in other research, to our knowledge. This was important because suggestions for new teaching methods should be palatable to staff who use them. The small sample size makes us reluctant to draw firm conclusions, so we view it as a preliminary study, which suggests that staff enjoyed leading both types of seminar.

Our study makes an important contribution to the evidence around using games in the classroom. Unlike many previous studies, our experiment employed a comparison group who completed a quiz, and we included an important control in the form of question type (questions that were covered in the seminar versus control lecture questions). Consequently, we have more confidence that (a) a seminar that involves information retrieval is beneficial to memory and (b) that the seminar helped memory specifically for the material that was covered (rather than improving, for example, confidence in testing more generally). Because we did not find that the board game was beneficial over the quiz it could be argued that the present study is uninformative to educators who should focus on research that informs about tasks that aid learning above traditional approaches. However, we propose that it is important to know when games are of similar utility so that we can make better-informed choices about how to use time and financial resources when planning teaching activities, allow for student choice of tasks, and, at a wider level, to avoid publication bias. Our results are consistent with those reported by Goldey and Espinosa (2020) who engaged students with a 'Cranium' style game during a seminar class. They showed that exam performance was similar to a comparison group who answered questions. Considering these results in the context of the mechanisms at work in learning information, it is possible that in the present study, and the study by Goldey and Espinosa, retrieval practice was responsible for the enhanced memory effect. Therefore, a teaching activity that incorporates this is generally always going to be useful irrespective of the specific format in which it is provided (see e.g. Agarwal et al., 2021; Agarwal & Bain, 2019).

However, there are limitations to this experiment. Because the data were collected anonymously, we were unable to analyse participants' exam performance to determine how well participants remembered the seminar material at the end of the course. But, we did not want to cause anxiety in participants who may have been reluctant to take part in the study if they knew we would later investigate exam performance. Like other practitioner studies, we also would prefer a larger sample size. We had a large drop out (n = 24, 51 per cent) by the follow-up questionnaire, and this shows the challenges of gathering data on learning activities that are not part of the day-to-day university experience. We also acknowledge the role of individual differences, whereby not all students will enjoy games. Some students may prefer a traditional quiz or question and answer sessions, and future research could explore whether particular types of games are more beneficial for individuals with certain characteristics, such as neurodiversity.

It is natural to interpret participants' superior follow-up performance on the seminar questions, relative to the lecture questions in terms of a retention of the material that was contained within the seminar. However, as all the material within the seminar could be accessed by students (e.g. lecture materials and reading through the online learning

environment), it is possible that participating in this seminar encouraged students to selectively revise the material during the 7-day retention interval based upon their reflection of their performance during the seminar. Future research could examine follow-up performance to distinguish between simple memory retention from engagement with the material (i.e. revision).

Game-based learning, then, does offer benefits, such as the opportunity to engage in retrieval practice and being enjoyable. In future we may look further at playful learning and how that could be incorporated to create safe and inclusive learning environments for students (e.g. Whitton, 2018; Whitton & Moseley, 2012).

In summary, we used an experiment to test the effectiveness of a board game for students' learning of biological psychology in a seminar. Although we found no difference between students' memory for material after playing a board game versus taking part in a quiz, performance of all students improved after the seminar, and a week later, compared to memory for material not included in the seminar. Furthermore, students in the board game group expressed more enjoyment compared to the quiz group. These data show that the well-established psychological effect of retrieval practice as a memory enhancer can be achieved by different types of activities including board games and quizzes. Consequently, games may have learning and memory benefits for this reason, as well as having the benefit of being fun and engaging for both students and staff.

The authors

Dr Emma Whitt
School of Psychology,
University of Nottingham
https://orcid.org/0000-0002-1694-2698

Dr Mark Haselgrove
School of Psychology,
University of Nottingham
https://orcid.org/0000-0001-8981-1181

These data were presented at the Enhancing Student Learning Through Innovative Scholarship conference and the BPS Division of Academics, Researchers & Teachers in Psychology conference.

Acknowledgements

This work was supported by the University of Nottingham Faculty of Science Education and Student Experience grant. We thank all the students who took part in the seminars and the staff who ran them.

Correspondence

Dr Emma Whitt
School of Psychology, University Park,
University of Nottingham, Nottingham,
NG7 2RD
Emma.Whitt@nottingham.ac.uk

References

Abramson, C.I., Burke-Bergmann, A.L., Nolf, S.L. & Swift, K. (2009). Use of board games, historical calendars, and trading cards in a history of psychology class. *Psychological Reports, 104*(2), 529–544. https://doi.org/10.2466/PR0.104.2.529-544

Ackerman, P.L. & Kanfer, R. (2009). Test length and cognitive fatigue: an empirical examination of effects on performance and test-taker reactions. *Journal of Experimental Psychology: Applied, 15*(2), 163–181. https://doi.org/10.1037/a0015719

Adesope, O.O., Trevisan, D.A. & Sundararajan, N. (2017). Rethinking the use of tests: A meta-analysis of practice testing. *Review of Educational Research, 87*(3), 659–701. https://doi.org/10.3102/0034654316689306

Agarwal, P.K. & Bain, P.M. (2019). *Powerful teaching: Unleash the science of learning*. Jossey Bass.

Agarwal, P.K., Nunes, L.D. & Blunt, J.R. (2021). Retrieval practice consistently benefits student learning: A systematic review of applied research in schools and classrooms. *Educational Psychology Review, 33*(4), 1409–1453. https://doi.org/10.1007/s10648-021-09595-9

Biggs, J.B. & Collis, K.F. (1982). *Evaluating the quality of learning: The SOLO taxonomy (Structure of the Observed Learning Outcome)*. Academic Press.

Bonwell, C. & Eison, J. (1991). *Active learning: Creating excitement in the classroom*. ASHE-ERIC Higher Education Report No. 1.

Børte, K., Nesje, K. & Lillejord, S. (2020). Barriers to student active learning in higher education. *Teaching in Higher Education*. https://doi.org/10.1080/13562517.2020.1839746

Clark, D.A. & Murphy, W. (2021). The efficacy of a classroom game for teaching APA style citation. *Teaching of Psychology, 48*(3), 209–214. https://doi.org/10.1177/0098628320977263

Dunlosky, J., Rawson, K.A., Marsh, E.J., Nathan, M.J. & Willingham, D.T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest, 14*(1), 4–58. https://doi.org/10.1177/1529100612453266

Freeman, S., Eddy, S.L., McDonough, M. et al. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America, 111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Garris, R., Ahlers, R. & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation and Gaming, 33*(4), 441–467. https://doi.org/10.1177/1046878102238607

Goldey, K.L. & Espinosa, A. (2020). Sculptorades, cloodles, and cameos, oh my! A cranium game for general psychology. *Teaching of Psychology*. https://doi.org/10.1177/0098628320979877

Hu, Y., Gallagher, T., Wouters, P., van der Schaaf, M. & Kester, L. (2022). Game-based learning has good chemistry with chemistry education: A three-level meta-analysis. *Journal of Research in Science Teaching*. https://doi.org/10.1002/tea.21765

Karakoç, B., Eryılmaz, K., Turan Özpolat, E. & Yıldırım, İ. (2022). The effect of game-based learning on student achievement: A meta-analysis study. *Technology, Knowledge and Learning, 27*(1), 207–222. https://doi.org/10.1007/s10758-020-09471-5

Lei, H., Chiu, M.M., Wang, D., Wang, C. & Xie, T. (2022). Effects of game-based learning on students' achievement in science: A meta-analysis. *Journal of Educational Computing Research*. https://doi.org/10.1177/07356331211064543

Marburger, D.R. (2001). Absenteeism and undergraduate exam performance. *The Journal of Economic Education, 32*(2), 99–109. https://doi.org/10.1080/00220480109595176

Mortiboys, A. (2010). *How to be an effective teacher in higher education answers to lecturers' questions*. McGraw-Hill: Open University Press.

National Committee of inquiry into higher education. (1997). Higher education in the learning society: Report of the national committee. In *NCIHE*.

Peck, A.C., Ali, R.S., Levine, M.E. & Matchock, R.L. (2006). Introductory psychology topics and student performance: Where's the challenge? *Teaching of Psychology, 33*(3), 167–170. https://doi.org/10.1207/s15328023top3303_2

Phillips, P., Abraham, C. & Bond, R. (2003). Personality, cognition, and university students' examination performance. *European Journal of Personality, 17*(6), 435–448. https://doi.org/10.1002/per.488

QAA (2019). Subject benchmark statement: Psychology. November. https://www.qaa.ac.uk/docs/qaa/subject-benchmark-statements/subject-benchmark-statement-psychology.pdf?sfvrsn=6935c881_13

Riopel, M., Nenciovici, L., Potvin, P. et al. (2019). Impact of serious games on science learning achievement compared with more conventional instruction: an overview and a meta-analysis. *Studies in Science Education, 55*(2), 169–214. https://doi.org/10.1080/03057267.2019.1722420

Robison, F.F. (2014). It's a game! Evaluation of a classroom game to enhance learning in an introductory counseling course 1. *Innovative Teaching*, *3*(1), Article 10. https://doi.org/10.2466/07.08.it.3.10

Roediger, H.L. & Karpicke, J.D. (2006). Test-enhanced learning: Taking memory tests imporves long-term retention. *Psychological Science*, *17*(3), 249–255. https://doi.org/10.1111/j.1467-9280.2006.01693.x

Sailer, M. & Homner, L. (2020). The gamification of learning: A meta-analysis. *Educational Psychology Review*, *32*(1), 77–112. https://doi.org/10.1007/s10648-019-09498-w

Scarlet, J. & Ampolos, L. (2013). Using game-based learning to teach psychopharmacology. *Psychology Learning and Teaching*, *12*(1), 64–70. https://doi.org/10.2304/plat.2013.12.1.64

Sheffield Hallam University. (2016). New board game teaches students about the brain. https://www4.shu.ac.uk/mediacentre/new-board-game-teaches-students-about-brain?filter=Psychology

Whitton, N. (2018). Playful learning: Tools, techniques, and tactics. *Research in Learning Technology*, *26*(1063519), 1–12. https://doi.org/10.25304/rlt.v26.2035

Whitton, N. & Moseley, A. (2012). *Using games to enhance learning and teaching: A beginner's guide*. Taylor & Francis.

Appendix

Test questions

Questions 1–4 were taken from the question cards in the seminar and questions 5-6 were taken from a lecture revision session. Asterisks identify answers that were coded as correct.

1. What substance is secreted in the ventricles of the brain?
    - Synovial fluid
    - Cerebrospinal fluid*
    - Dopamine
    - Cortisol

2. Which area of the brain is involved in executive functions?
    - Prefrontal*
    - Premotor
    - Frontal
    - Temporal

3. Which area of the brain stem regulates cardiac systems?
    - Pons
    - Cerebellum
    - Medulla Oblongata*
    - Cerebrum

4. If a person has an anterograde amnesia which structure within the temporal lobe is damaged?
    - Amygdala
    - Wernicke's area
    - Lateral ventricle
    - Hippocampus*

5. The 'groove' that separates the temporal and frontal lobe is the
    - Central sulcus
    - Lateral sulcus*
    - Cingulate sulcus
    - Calcarine sulcus

6. Which receptor type produces fast acting changes on a membrane?
    - Serotonin
    - Metabotropic
    - Ionotropic*
    - Dopamine