



The role of achievement emotions in team-based learning

Kah Loong Chue¹ · Ethan Wong¹ · Yvonne Bee Gek Seng¹ · Stefanie Yen Leng Chye¹ · Caroline Koh¹ · Gabriel Goh¹

Received: 20 November 2022 / Accepted: 13 August 2024

© The Author(s), under exclusive licence to Springer Nature Singapore Pte Ltd. 2024

Abstract

Team-based learning (TBL) is an alternative instructional method that has been shown to lead to positive concrete academic performance outcomes. However, whilst academic performance is important, we should also not neglect other non-tangible student outcomes such as the emotions experienced during the TBL sessions and improvements in student's learning. Hence, in the current study, we aim to examine (1) the academic performance of TBL vs traditional lessons, (2) the differences in achievement emotions of student in TBL vs traditional lessons and (3) the perceived effectiveness of TBL lessons. A within-subjects research design was employed in which students participated in sessions using the TBL approach followed by sessions using the normal approach. Participants were 239 postgraduate students (81 men and 158 women) enrolled in the field of education. Measures used were the achievement emotions questionnaire, a perceived effectiveness of TBL questionnaire and the students performance on a quiz at the end of the module. Results indicated that students had a higher level of enjoyment and a lower level of boredom and anger in TBL lessons. From both the individual and team perspective, students had positive perceptions about the effectiveness of TBL. However, students performed better for topics that were taught via traditional methods compared to topics taught via TBL.

Keywords Team-based learning · Achievement emotions · Academic performance · Emotions · Team learning

1 Introduction

Higher education is of utmost importance in today's world, and contemporary society places a large emphasis on quality teaching at that level. There is a constant need to improve upon and refine how tertiary-level students apply course knowledge and develop future-ready skills that are in tandem with the twenty-first century workforce. To date, much of higher education utilizes traditional teaching methodologies that usually involve a one-way flow of communication, resulting in a passive learning style for the students

✉ Kah Loong Chue
kahloong.chue@nie.edu.sg

¹ Psychology and Child & Human Development Department, National Institute of Education, Nanyang Technological University, Nanyang, Singapore

(Crisol-Moya et al., 2020). Comparatively, alternative learning paradigms that involve active learning processes in the classroom often result in active engagement of students in their learning, increasing their motivation and their ability to apply their learning outside of the classroom (Johnson & Johnson, 2008). With this in mind, it is important to implement instructional methods for students that encourage active participation in the classroom.

Team-based learning (TBL) offers one such alternative instructional method. As a teaching methodology, TBL has been shown to lead to many academic-related positive outcomes, including greater perceived effectiveness of teaching (Allen et al., 2013), enhanced critical thinking skills (Espey, 2017), higher level of motivation (Jeno et al., 2017), improved student–instructor contact (Persky & Pollack, 2011), better examination performance (Koles et al., 2010), improved class participation (Grady, 2011; Kohtz et al., 2017) and improved student self-efficacy (Paulet Juncà et al., 2017). Whilst it is natural and important to focus on concrete academic outcomes as well as the effectiveness of the sessions, one should also not neglect the emotional aspects involved in TBL. Thus, the aims of this study were to examine (1) the differences in achievement emotions of students in TBL vs traditional lessons and (2) the perceived effectiveness of TBL lessons.

1.1 Team-based learning

Team-based learning, developed by Dr. Larry Michaelsen, is a structured method of teaching that emphasizes student collaborations during classroom learning (Michaelsen & Sweet, 2008). It has its basis in constructivist learning theory (Hrynchak & Batty, 2012) and is posited to lead to positive learning outcomes via enhancing reconsolidation of learnt material and student accountability (Schmidt et al., 2019; Stein et al., 2015). There are three main phases involved. In the initial phase, students study and review the assigned reading materials before the classes commence. The TBL paradigm considers it unnecessary for lecturers and tutors to deliver content if the pre-class reading materials provided to students are already at a level appropriate for their understanding (Michaelsen & Sweet, 2008).

The second phase occurs at the beginning of the lesson. An Individual Readiness Assurance Test (IRAT) is administered to assess students on the reviewed materials. This is followed by a Team Readiness Assurance Test (TRAT) in which the students respond to the same items as the IRAT, but in a team of three to five members. Students who have not done their pre-class readings will hinder both their own as well as their groups' performance. In this way, this stage renders students accountable for their own and their teammates' learning, which may lead to an increase in the students' motivation to complete pre-class readings (Stein et al., 2015). This is in contrast with traditional lecture-tutorial systems, where there may be less student accountability, which, in turn, may result in a lower level of engagement (Axelson & Flick, 2010; Michaelsen & Sweet, 2008). After the TRAT, the students are able to clarify any further doubts on the content with the tutor. In the third phase, the student teams work on real-world scenario questions that are related to the content of the session. This not only gives the students much needed practice in applying learnt knowledge, but it also provides them with an opportunity to work collaboratively in problem solving. Finally, the teams have to complete an intra-group peer assessment. The peer assessment not only serves a summative function by ensuring equity in grading, but it also serves a formative function by providing students with peer feedback on their work.

Although meta-analytical studies have indicated that TBL does produce a significant impact on academic outcomes (Liu & Beaujean, 2017; Swanson et al., 2017), the researchers admitted that there were several limitations and inconsistencies across studies in the process of their search. The studies that emerged from the review were over-represented by samples in the field of medicine (Swanson et al., 2017). Moreover, Liu and Beaujean (2017) found that many of the studies could not be used for their analysis as they either did not include a comparison group, did not adequately describe the intervention or used inconsistent learning outcome data. The present study aims to augment the existing literature by investigating the effectiveness of TBL to postgraduate students in the field of education. It also uses a within-subject research design that is intended to reduce the influence of confounding variables, such as differences in teaching effectiveness of different tutors, students' prior knowledge and assessment difficulty and format. Instead of looking at how different cohorts of students compare to each other in terms of academic performance when different teaching methodologies are utilized, we aimed to examine the differences in performance of a single cohort within a single course module.

Generally, the previous studies have shown that students perceived TBL to be effective as it provides them with a high degree of satisfaction, engagement and develops their higher-order cognitive skills (Frame et al., 2015; Walker & Guo, 2017). In this instance, TBL was a significant departure from what students were used to, and there was the possibility of resistance to its implementation. Furthermore, as teamwork is integral to TBL (Michaelsen & Sweet, 2008), it was also important to be aware of their perceptions of teamwork as these students will be deployed as teachers after completing their postgraduate studies. Acceptance of TBL at the individual and team level may eventually impact pedagogical decisions in their future career. As such, we also assess the students' perceived effectiveness of TBL and teamwork in the present study.

1.2 Achievement emotions

Teaching methodologies based on active learning can also bring about other positive outcomes, such as by enhancing students' enjoyment of lessons or rendering lessons less boring (Kharb et al., 2013). Although it has been theorized that TBL has other positive influences in the classroom besides improving students grades (Michaelsen et al., 2011), there has been relatively sparse research on the impact of TBL on students achievement emotions. To fill this gap in the literature, the present study also sought to investigate the efficacy of TBL on emotions as compared to traditional instructional methods. To understand these effects, we applied the lenses of achievement emotions as proposed by Pekrun et al. (2007).

Achievement emotions are defined as emotions tied directly to achievement activities or outcomes (Pekrun et al., 2007). The arousal of these emotions is based on an individual's subjective evaluation of the value and control that they place on these activities and outcomes. The type of emotion that is activated is dependent on whether it is outcome-focused or activity-focused, as well as different patterns of appraisals and control. For example, during a learning activity, a positive appraisal coupled with a high locus of control would instigate enjoyment in the student, whereas a negative appraisal coupled with a high locus of control would instigate anger. Conceivably, students will enjoy a class session if they find meaning and were sufficiently competent in dealing with the learning activities. Conversely, anger may be experienced if the students feel competent but activities require an unreasonable amount of effort or time. Alternatively, if the activities hold no value for the student, boredom would be felt,

regardless of the level of competency. The control-value theory of achievement emotions has been corroborated by empirical studies that showed corresponding correlations between these emotions with perceived competence and task value (Peixoto et al., 2016; Pekrun et al., 2011).

The relation between achievement emotions and academic achievement was examined thoroughly in a longitudinal study conducted by Pekrun et al. (2017). The researchers concluded that positive emotions positively predict academic achievement and negative emotions negatively predict academic achievement. Moreover, the relationship is reciprocal, that is, positive/negative achievement predicts the corresponding emotions (Pekrun et al., 2017). What then are the means in which emotions affect achievement? Artino et al. (2012) described four pathways via which a students' emotions can affect their performance: by affecting state-dependent memory, by influencing the type of cognitive strategies that students use, by increasing or decreasing cognitive load in working memory and by facilitating intrinsic or extrinsic motivation in students. Outcomes are subsequently fed back to the individual, that might lead to changes in students' perceived value and control of the situation (Artino et al., 2012).

Although several studies have indicated that students enjoy TBL lessons (e.g. Gomez et al., 2010), empirical studies examining TBL and other achievement emotions are relatively scarce. Nonetheless, Zschocke et al. (2015) conducted an empirical study pertaining to emotions and group work. The results from the study indicated that positive emotions are associated with cognitive benefits, whereas negative emotions are associated with group processes and task characteristics. As TBL is predominantly team-based, this may indicate that elements of TBL such as its self-referential feedback and accountability practices may contribute towards increasing positive emotions and lowering negative emotions (Chue, 2020). Consequently, this may decrease the cognitive load in students' working memory (Artino et al., 2012) which would be beneficial in test preparation.

2 Research questions

In summary, the present study aimed to answer these research questions:

- 1) Do students experience a higher level of positive emotions and a lesser level of negative emotions in TBL lessons as compared to traditional lessons?
- 2) Do students perceive that TBL lessons are effective at the individual and team level?

We hypothesized that.

- 1) The level of enjoyment in TBL lessons will be higher than traditional lessons.
- 2) The level of boredom and anger in TBL lessons will be lower than traditional lessons.
- 3) Students will perceive the effectiveness of TBL lessons to be higher than the mean score of 3 at both the individual and team levels.

3 Methods

3.1 Participants

Participants for this study were recruited from a cohort of students in the field of education. The students were enrolled in the Postgraduate Diploma of Education and will be

deployed to teach in schools after graduation. In this instance, postgraduate students refer to students in the programme that would have completed their undergraduate degree in any discipline. A total of 239 student teachers (81 men and 158 women) completed all aspects of the study. The mean age was 26.9 years, $SD=3.46$. Prior to data collection and the intervention, permission was sought and approved by the university's ethics board. Consent was also obtained for all participants.

3.2 Measures

Academic performance: Students' academic performance was assessed by their scores on a closed-book final quiz. The quiz had 25 multiple-choice items out of which 10 items were on the TBL topics (5 items per session) and 15 items were on the non-TBL topics (5 items per session). Multiple-choice items were used as they are graded objectively and thus allow for a rigorous comparison between scores. The score for each student was split into two separate scores. The first score was based on topics taught using TBL (Score_TBL) whilst the second score was based on topics taught using the traditional method (Score_Traditional). Items for both TBL and non-TBL topics were designed to assess understanding of the topics and were evaluated to be similar in difficulty levels. Both scores were then transformed into percentages to enable comparisons between them.

Achievement emotions: Students' achievement emotions were assessed using a modified version of the achievement emotions questionnaire (AEQ; Pekrun et al., 2011). The AEQ has been used and validated in different contexts (e.g. Bhansali & Sharma, 2019; Jeon, 2014; Peixoto et al., 2015). Three scales of activity-related achievement emotions, specifically enjoyment, boredom and anger, were selected from the questionnaire and administered to the participants. Each scale was measured on a 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree, whereby higher values indicate higher levels of emotions. As the original questionnaire pertained to Math classes, terms specifying Math classes were amended to TBL lessons. Sample items include "I look forward to the TBL lessons" (Enjoyment), "I think the TBL lessons are boring" (Boredom) and "I get angry because the material in TBL lessons is so difficult" (Anger). The scales demonstrated high internal consistency for both TBL and traditional lessons ($\alpha_{\text{Enjoyment_TBL}}=0.93$, $\alpha_{\text{Enjoyment_Traditional}}=0.92$, $\alpha_{\text{Boredom_TBL}}=0.89$, $\alpha_{\text{Boredom_Traditional}}=0.90$, $\alpha_{\text{Anger_TBL}}=0.90$, $\alpha_{\text{Anger_Traditional}}=0.94$).

Perceived effectiveness of TBL: Students' perceived effectiveness of TBL was assessed using a 15-item questionnaire developed and validated by Vasan et al. (2009). The questionnaire comprised of two dimensions. The first dimension (Individual Effectiveness) assesses students' perception of the effectiveness of TBL from an individual viewpoint and consists of eight items. The second dimension (Team Effectiveness) assesses students' perceptions of inter-group relations in TBL and consists of seven items. Sample items include "I learned useful information during the TBL sessions" (Individual Effectiveness) and "My team worked well together" (Team Effectiveness). Both dimensions were measured using a 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree and demonstrated high internal consistency ($\alpha_{\text{Individual Effectiveness}}=0.93$ and $\alpha_{\text{Team Effectiveness}}=0.86$).

3.3 Procedure

The present study took place in a 6-week course on assessment and used a within-groups research design. The within-groups research design was selected because the students were

split into several classes with different tutors teaching each class, with the PI of the research study as the tutor for one class. This reduced the individual differences between students as well as the impact of the tutor. To increase the fidelity of the TBL sessions, the tutors were trained in TBL before the semester began. The structure of the sessions and their respective topics are illustrated in Fig. 1. Each session lasted for a period of 2 h. The traditional method of teaching was used in the first, fourth and fifth session whilst the second and third session used the TBL approach. The AEQ was administered at the end of Session 3 and Session 5 to assess students emotions during lessons conducted using TBL and traditional methods, respectively. The perceived effectiveness of TBL questionnaire was also administered at the end of Session 3. Students took a standardized final summative quiz in the sixth session. The final quiz assessed students on all the topics in the course.

3.3.1 TBL intervention

A typical TBL structure was adopted in each of the TBL sessions. Students were assigned into permanent teams of three to five students and provided with assigned readings before the sessions commenced. Each of the sessions began with students taking the IRAT that was administered online in a learning management system. The IRAT comprised of 10 multiple-choice items and tested the knowledge and understanding of the material that the students have studied. Students had 15 min to complete the IRAT. To encourage students to read the materials beforehand, the IRAT results were scored and contributed to the final grade of the students.

Next, the students took the TRAT, which was the same 10 items as the IRAT, in their assigned teams. The design of the classroom was such that tables and chairs were easily moveable to a layout conducive for group work. During the TRAT, students had to discuss and settle on a consensus before checking their answers using scratch cards. In this way, the students were given immediate feedback on their answers. If a team could form an argument as to why their chosen answer should be accepted as correct in lieu of the model answer, they were allowed to make appeals to the tutor. Students took approximately 30 min to complete the TRAT. The scores on the TRAT did not contribute to the final grade of the students.

Finally, students had to reconvene in teams to solve application questions for the remainder of the session. For example, in the second session, teams had to critique a test paper and plan an assessment in their subject area. Due to limited time, the teams did not present their

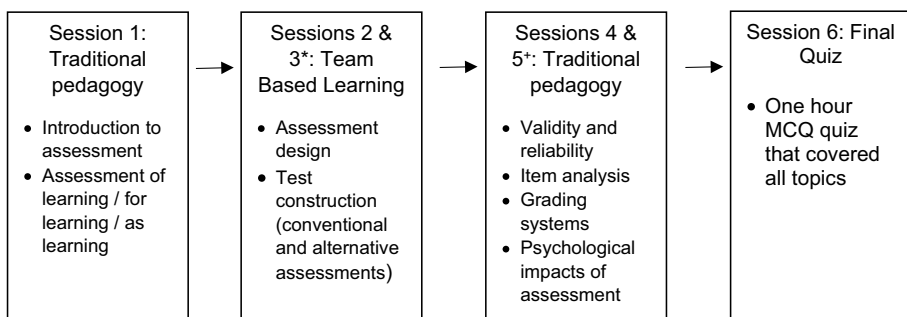


Fig. 1 Structure of sessions in the course. *AEQ and perceived effectiveness of TBL survey administered, †AEQ administered

solutions to each other. The solutions were submitted to the tutor through a learning management system. Tutors would then provide written feedback to the teams by the next session. For the same reason, peer assessment was not conducted at the end of the TBL sessions. Rather, it was conducted at the end of the final session. The application questions were not scored as the focus was on formative feedback that would be provided to students. However, peer assessment was scored and contributed a small portion to the final grade of the students.

3.3.2 Traditional pedagogy

In the sessions where traditional pedagogy was performed, tutors had to present the materials using powerpoint slides. For example, in a segment for Session 4, tutors usually presented the concepts and technical details of item analysis, followed by a discussion on the practical applications in educational settings. However, students need not read up on the materials beforehand, nor were they expected to problem-solve in those lessons.

3.4 Data analysis

Data from the survey and final quiz were analysed using SPSS ver 26. Initially, descriptive statistics and zero-order correlations were computed. To compare differences in achievement emotions between the TBL and traditional methods, a paired sample *t*-test was used. To determine whether students perceive TBL to be effective, a one-sample *t*-test comparing the mean values with the average score of 3 was used. Effect sizes for both tests were computed using Cohen's *d* (small effect = 0.2, medium effect = 0.5 and large effect = 0.8).

4 Results

The descriptive statistics and zero-order correlations of the variables are reported in Table 1. As expected, enjoyment had a negative association with boredom and anger in both TBL and traditional lessons. Perceived effectiveness of both individual and team aspects of TBL had positive associations with enjoyment but negative associations with boredom and anger. Surprisingly, there were no significant associations between the quiz scores and achievement emotions.

Comparisons of achievement emotions between TBL and traditional lessons are shown in Table 2. As hypothesized, the level of enjoyment was significantly higher whilst the levels of boredom and anger were significantly lower in TBL lessons. All the differences exhibited a small effect size.

Finally, the results indicated that the perceived effectiveness of TBL was significantly higher than average from both the individual ($M_{diff}=0.77$, $t=16.0$, $p<0.001$, $d=1.04$) and team perspective ($M_{diff}=1.25$, $t=36.4$, $p<0.001$, $d=2.36$).

5 Discussion

5.1 Achievement emotions

Results from the present study indicated that students found sessions conducted using TBL more enjoyable, less boring and less angering. Viewing from a control-value theory

Table 1 Descriptive statistics and zero-order correlations of variables

No.	Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10
1	Score_TBL	75.2	14.2	-									
2	Score_traditional	77.7	13.5	0.54**	-								
3	Enjoyment_TBL	3.48	0.84	0.04	-0.04	-							
4	Boredom_TBL	2.26	0.89	-0.12	-0.02	-0.74**	-						
5	Anger_TBL	1.85	0.80	-0.02	.06	-0.53**	.59**	-					
6	Enjoyment_traditional	3.30	0.86	0.01	-0.07	.24**	-0.22**	-0.16*	-				
7	Boredom_traditional	2.42	0.92	0.03	.03	-0.23**	0.30**	0.25**	-0.58**	-			
8	Anger_traditional	2.01	0.92	0.00	-0.01	-0.31**	0.36**	0.33**	-0.45**	0.74**	-		
9	Individual effectiveness	3.77	0.74	0.04	-0.06	0.75**	-0.62**	-0.50**	0.26**	-0.23**	-0.32**	-	
10	Team effectiveness	4.25	0.53	-0.05	-0.06	0.49**	-0.36**	-0.40**	0.13*	-0.10	-0.15*	0.53**	-

* $p < .05$ and ** $p < .01$, 2) Labels ending in TBL = measurements based on TBL sessions and labels ending in traditional = measurements based on traditional sessions

Table 2 Comparisons between TBL and traditional lessons

No.	Variable	M_{TBL} (SD)	M_{Trad} (SD)	M_{Diff} (SD)	t	p	d
1	Enjoyment	3.48 (.84)	3.30 (.86)	.18 (1.05)	2.70	0.007	0.17
2	Boredom	2.26 (.89)	2.42 (.92)	-0.16 (1.08)	-2.25	0.026	0.15
3	Anger	1.85 (.80)	2.01 (.92)	-0.17 (1.00)	-2.58	0.011	0.16

perspective, we hypothesized that elements of TBL may have led to this findings in three ways—provision of immediate and frequent feedback, incorporation of real-world exercises and its accountability practices.

First, studies have shown that immediate feedback is linked to the development of self-efficacy beliefs (Artino et al., 2012), thus increasing the level of perceived control in students. TBL involves a readiness assurance procedure comprising the IRAT and TRAT, which provides students with effective and self-referential feedback. During the TRAT, students take an assessment in teams. They select their answers via scratch cards which provide them with immediate feedback about the accuracy of their answers. If an incorrect answer was selected, they would conduct discussions with their team members and tutors to correct their misconceptions. Furthermore, in the application exercises, tutors are able to provide written feedback on their solutions by the following week. This cycle of feedback is repeated in every TBL session. These opportunities for immediate and frequent feedback are not usually prominent in traditional learning pedagogies.

Second, TBL can also increase students' perceived value of learning by linking the application exercises to problems that they may face in the real world. According to Wigfield and Eccles (1992), activities that are perceived to assist with future goal attainment are regarded as having high utility value and thus greater perceived value. TBL provides a context for authentic learning that may help students see the relevance in their future careers. For instance, planning an assessment in their teaching area is an important aspect of teaching, and thus, incorporating this into the application exercises will be considered to have a high utility value. Similar to the previous point, these exercises are repeated in every TBL session and may not be present if a traditional method of teaching is employed.

Third, TBL may have increased perceived control and value in students working in groups by incorporating individual assessments as an accountability measure. By implementing an individual assessment, TBL ensures that most, if not all, students prepare for the lessons. This may have a dual impact of increasing positive emotions via increased cognitive benefits and decreasing negative emotions via stronger interactive processes (Zschocke et al., 2015). Cognitively, students would have a basic knowledge of the topic beforehand—they would be in a better position to further understand and internalize the materials. Moreover, students had opportunities to evaluate their peers within the group on their level of preparedness. Perceived control is thus increased, leading to a higher level of enjoyment. Process-wise, when peers are prepared for discussions, students may perceive a greater sense of value in lessons, and their interactions within each team. In contrast, if their peers are not prepared for the sessions, students may have to spend unnecessary time to explain basic concepts to them. In this case, students are more likely to experience boredom and anger.

Interestingly, achievement emotions were found to be unrelated to actual academic performance, and this would appear to diverge from the emotion–performance pathways described by Artino et al. (2012). A higher level of enjoyment in TBL sessions would

supposedly lead to a greater decrease in cognitive load, and thus a higher level of performance when students prepare for the quiz. However, it does not appear to be the case here. A possible reason may be that the contrasts between the levels of enjoyment are not sufficiently substantial to cause a significant difference in cognitive loads. As the traditional pedagogy in this study also involves discussion-based activities, this may imply that effective class discussions have a similar impact on the cognitive loads of students.

5.2 Perceived effectiveness of TBL

In general, students had positive perceptions about the effectiveness of TBL. From an individual perspective, the students felt that the activities within TBL were useful and helped to improve their understanding of the course materials. From the team perspective, they felt that the team dynamics worked well for them. Opportunities to collaborate and solve problems in a team were effective within the TBL context. This was similar to the previous research conducted (Vasan et al., 2009). Unsurprisingly, the perception of effectiveness was positively correlated with positive achievement emotions and negatively correlated with negative achievement emotions. Specifically, students who perceived TBL to be more effective were more likely to experience greater enjoyment and less boredom and anger. This finding corroborates the control-value theory account of achievement emotions. Students who feel that TBL is effective at the individual and team level will tend to appraise the lessons at a high value and vice versa.

Taken together, the results suggest that TBL may be efficacious as a teaching methodology. For instance, TBL lessons may be more effective in garnering student interest and motivation in the classroom. In higher education, enjoyment has been found to be a significant predictor of motivation and increased participation in lessons (Lucardie, 2014), whilst class-related boredom has been linked to reduced intrinsic motivation (Tsai et al., 2008). Similarly, activating the emotion of enjoyment may lead to higher self-regulation, the use of flexible learning strategies and has an indirect effect on fostering teachers' enthusiasm (Pekrun et al., 2007).

Interestingly, perceived effectiveness of TBL was found to be unrelated to actual academic performance. This indicates that whilst students feel that TBL is effective in developing their knowledge and skills, this does not translate into eventual performance in examinations. This finding was also reported in Vasan et al. (2009) who found that there were no significant differences in mean ratings of perceived effectiveness across different grades. As the questionnaire was administered immediately after the TBL sessions, it is possible that students were highly receptive to the approach because the level of engagement was higher than what they were accustomed to. Moreover, as the students were post-graduates, they tended to be more mature and self-directed in their learning.

5.3 Limitations and future research

Several limitations of the present study might have impacted on the results. First, due to limits in the curriculum structure, different topics in different sessions were assigned for TBL and non-TBL lessons. There were five sessions in total and although the first session was an introductory session, it could be said that students had slightly more exposure to the traditional methods of teaching (approximately 2.5 traditional sessions vs 2 TBL sessions). Second, due to time constraints within the sessions, the full TBL procedure was not implemented, and students had no opportunity to present their solutions. However, this may not

have a severe adverse impact on the emotions experienced as it was likely that other elements of TBL were significant contributors of the achievement emotions from a control-value theory perspective. Third, the gender ratio in the sample was approximately 2:1, with more women being represented. As the prevalent consensus was that women are more emotional, the results may not be generalizable to other programmes that are traditionally dominated by men (e.g. engineering). Fourth, in order to keep the questionnaires manageable, the full achievement emotions questionnaire was not able to be included as part of this study. The present study confined its investigation of achievement emotions to only class-related achievement emotions, omitting learning-related and test-related achievement emotions. Given that the different achievement emotions can have different, nuanced effects on other learning outcomes, it is of interest to further investigate the effects of TBL on other achievement emotions in subsequent studies.

Funding This work was supported by the Edex Grant 2018/2019 from the Teaching, Learning and Pedagogy Division, NTU.

Declarations

Conflict of interest There are no competing interests for this study.

References

- Allen, R. E., Copeland, J., Franks, A. S., Karimi, R., McCollum, M., Riese, D. J., & Lin, A. Y. F. (2013). Team-based learning in US colleges and schools of pharmacy. *American Journal of Pharmaceutical Education*, 77(6), 115. <https://doi.org/10.5688/ajpe776115>
- Artino, A. R., Holmboe, E. S., & Durning, S. J. (2012). Control-value theory: Using achievement emotions to improve understanding of motivation, learning, and performance in medical education: AMEE Guide No. 64. *Medical Teacher*, 34(3), e148–e160. <https://doi.org/10.3109/0142159X.2012.651515>
- Chue, K. L. (2020). Team-Based Learning, Achievement Emotions and Personality Traits. *Diversifying Learner Experience: A kaleidoscope of instructional approaches and strategies*, 29–41.
- Axelson, Rick D., & Flick, Arend. (2010). Defining student engagement. *Change: The Magazine of Higher Learning*, 43(1), 38–43. <https://doi.org/10.1080/00091383.2011.533096>
- Bhansali, A., & Sharma, M. D. (2019). The Achievement Emotions Questionnaire: Validation and implementation for undergraduate physics practicals. *International Journal of Innovation in Science and Mathematics Education*. <https://doi.org/10.30722/ijisme.27.09.003>
- Crisol-Moya, E., Romero-López, M. A., & Caurcel-Cara, M. J. (2020). Active methodologies in higher education: Perception and opinion as evaluated by professors and their students in the teaching-learning process. *Frontiers in Psychology*, 11, 1703.
- Espey, M. (2017). Enhancing critical thinking using team-based learning. *Higher Education Research & Development*, 37(1), 15–29. <https://doi.org/10.1080/07294360.2017.1344196>
- Frame, T. R., Cailor, S. M., Gryka, R. J., Chen, A. M., Kiersma, M. E., & Sheppard, L. (2015). Student perceptions of team-based learning vs traditional lecture-based learning. *American Journal of Pharmaceutical Education*, 79(4), 51. <https://doi.org/10.5688/ajpe79451>
- Gomez, E. A., Wu, D., & Passerini, K. (2010). Computer-supported team-based learning: The impact of motivation, enjoyment and team contributions on learning outcomes. *Computers & Education*, 55(1), 378–390. <https://doi.org/10.1016/j.compedu.2010.02.003>
- Grady, S. E. (2011). Team-based Learning in Pharmacotherapeutics. *American Journal of Pharmaceutical Education*, 75(7), 136. <https://doi.org/10.5688/ajpe757136>
- Hrynchak, P., & Batty, H. (2012). The educational theory basis of team-based learning. *Medical Teacher*, 34(10), 796–801. <https://doi.org/10.3109/0142159x.2012.687120>
- Jeno, L. M., Raaheim, A., Kristensen, S. M., Kristensen, K. D., Hole, T. N., Haugland, M. J., & Mæland, S. (2017). The relative effect of team-based learning on motivation and learning: A self-determination theory perspective. *CBE—Life Sciences Education*, 16(4), ar59. <https://doi.org/10.1187/cbe.17-03-0055>

- Jeon, J. (2014). Development and construct validation of the achievement emotions questionnaire-korean middle school science(AEQ-KMS). *Journal of The Korean Association For Research In Science Education*, 34(8), 745–754. <https://doi.org/10.14697/jkase.2014.34.8.0745>
- Johnson, R. T., & Johnson, D. W. (2008). active learning: Cooperation in the classroom. *The Annual Report of Educational Psychology in Japan*, 47, 29–30. https://doi.org/10.5926/arepj1962.47.0_29
- Kharb, P. (2013). The learning styles and the preferred teaching-learning strategies of first year medical students. *Journal of Clinical and Diagnostic Research*. <https://doi.org/10.7860/jcdr/2013/5809.3090>
- Kohtz, C., Hoadley, T., Liphart, J., Siegel, S., Briggs, K., Clark, S., Bonney, L. A., & Tillis, K. M. (2017). Adopting team-based learning: translating evidence into practice. *Nurse Educator*, 42(5), 218–221. <https://doi.org/10.1097/NNE.0000000000000388>
- Koles, P. G., Stolfi, A., Borges, N. J., Nelson, S., & Parmelee, D. X. (2010). The impact of team-based learning on medical students' academic performance. *Academic Medicine*, 85(11), 1739–1745. <https://doi.org/10.1097/acm.0b013e3181f52bed>
- Liu, S. N. C., & Beaujean, A. A. (2017). The effectiveness of team-based learning on academic outcomes: A meta-analysis. *Scholarship of Teaching and Learning in Psychology*, 3(1), 1–14. <https://doi.org/10.1037/stl0000075>
- Lucardie, D. (2014). The impact of fun and enjoyment on adult's learning. *Procedia-Social and Behavioral Sciences*, 142, 439–446. <https://doi.org/10.1016/j.sbspro.2014.07.696>
- Michaelsen, L. K., & Sweet, M. (2008). The essential elements of team-based learning. *New Directions for Teaching and Learning*, 2008(116), 7–27. <https://doi.org/10.1002/tl.330>
- Michaelsen, L. K., Sweet, M., & Parmelee, D. X. (Eds.). (2011). *team-based learning: small group learning's next big step: New directions for teaching and learning* (Vol. 103). John Wiley & Sons.
- Paulet Juncà, G., Belli, D., & Bajwa, N. M. (2017). Team-based learning to contextualise evidence-based practice for residents. *Medical Education*, 51(5), 542–543. <https://doi.org/10.1111/medu.13297>
- Peixoto, F., Mata, L., Monteiro, V., Sanches, C., & Pekrun, R. (2015). The achievement emotions questionnaire: Validation for pre-adolescent students. *European Journal of Developmental Psychology*, 12(4), 472–481.
- Peixoto, F., Sanches, C., Mata, L., & Monteiro, V. (2016). How do you feel about math?: Relationships between competence and value appraisals, achievement emotions and academic achievement. *European Journal of Psychology of Education*, 32(3), 385–405. <https://doi.org/10.1007/s10212-016-0299-4>
- Pekrun, R., Frenzel, A. C., Goetz, T., & Perry, R. P. (2007). The control-value theory of achievement emotions. *Emotion in Education*. <https://doi.org/10.1016/b978-012372545-5/50003-4>
- Pekrun, R., Goetz, T., Frenzel, A. C., Barchfeld, P., & Perry, R. P. (2011). Measuring emotions in students learning and performance: The achievement emotions questionnaire (AEQ). *Contemporary Educational Psychology*, 36(1), 36–48. <https://doi.org/10.1016/j.cedpsych.2010.10.002>
- Pekrun, R., Lichtenfeld, S., Marsh, H. W., Murayama, K., & Goetz, T. (2017). Achievement emotions and academic performance: longitudinal models of reciprocal effects. *Child Development*, 88(5), 1653–1670. <https://doi.org/10.1111/cdev.12704>
- Persky, A. M., & Pollack, G. M. (2011). A modified team-based learning physiology course. *American Journal of Pharmaceutical Education*, 75(10), 204. <https://doi.org/10.5688/ajpe7510204>
- Schmidt, H. G., Rotgans, J. I., Rajalingam, P., & Low-Beer, N. (2019). A psychological foundation for team-based learning. *Academic Medicine*, 94(12), 1878–1883. <https://doi.org/10.1097/acm.00000000000002810>
- Stein, R. E., Colyer, C. J., & Manning, J. (2015). Student accountability in team-based learning classes. *Teaching Sociology*, 44(1), 28–38. <https://doi.org/10.1177/0092055x15603429>
- Swanson, E., McCulley, L. V., Osman, D. J., Scammacca Lewis, N., & Solis, M. (2017). The effect of team-based learning on content knowledge: A meta-analysis. *Active Learning in Higher Education*, 20(1), 39–50. <https://doi.org/10.1177/1469787417731201>
- Tsai, Y. M., Kunter, M., Lüdtke, O., Trautwein, U., & Ryan, R. M. (2008). What makes lessons interesting? The role of situational and individual factors in three school subjects. *Journal of Educational Psychology*, 100(2), 460–472. <https://doi.org/10.1037/0022-0663.100.2.460>
- Vasan, N. S., DeFouw, D. O., & Compton, S. (2009). A survey of student perceptions of team-based learning in anatomy curriculum: Favorable views unrelated to grades. *Anatomical Sciences Education*, 2(4), 150–155. <https://doi.org/10.1002/ase.91>
- Walker, Z. M., & Zheng, T. G. (2017). Adopting team-based learning for in-service teachers: A case study. *International Journal for the Scholarship of Teaching and Learning*. <https://doi.org/10.20429/ijstol.2017.110106>
- Wigfield, A., & Eccles, J. S. (1992). The development of achievement task values: A theoretical analysis. *Developmental Review*, 12(3), 265–310. [https://doi.org/10.1016/0273-2297\(92\)90011-p](https://doi.org/10.1016/0273-2297(92)90011-p)

Zschocke, K., Wosnitza, M., & Bürger, K. (2015). Emotions in group work: Insights from an appraisal-oriented perspective. *European Journal of Psychology of Education, 31*(3), 359–384. <https://doi.org/10.1007/s10212-015-0278-1>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.