Team cohesiveness, team size and team performance in team-based learning teams

Britta M Thompson,[1,2] Paul Haidet,[3] Nicole J Borges,[4] Lisa R Carchedi,[5] Brenda J B Roman,[6] Mark H Townsend,[7] Agata P Butler,[8] David B Swanson,[9] Michael P Anderson[10] & Ruth E Levine[11]

OBJECTIVES The purpose of this study was to explore the relationships among variables associated with teams in team-based learning (TBL) settings and team outcomes.

METHODS We administered the National Board of Medical Examiners (NBME) Psychiatry Subject Test first to individuals and then to teams of Year three students at four medical schools that used TBL in their psychiatry core clerkships. Team cohesion was analysed using the Team Performance Scale (TPS). Bivariate correlation and linear regression analysis were used to analyse the relationships among team-level variables (mean individual TPS scores for each team, mean individual NBME scores of teams, team size, rotation and gender make-up) and team NBME test scores. A hierarchical linear model was used to test the effects of individual TPS and individual NBME test scores within each team, as well as the effects of the team-level variables of team size, team rotation and gender on team NBME test scores. Individual NBME test and TPS scores were nested within teams and treated as subsampling units.

RESULTS Individual NBME test scores and individual TPS scores were positively and statistically significantly ($p < 0.01$) associated with team NBME test scores, when team rotation, team size and gender make-up were controlled for. Higher team NBME test scores were associated with teams rotating later in the year and larger teams ($p < 0.01$). Gender make-up was not significantly associated.

CONCLUSIONS The results of an NBME Psychiatry Subject Test administered to TBL teams at four medical schools suggest that larger teams on later rotations score higher on a team NBME test. Individual NBME test scores and team cohesion were positively and significantly associated with team NBME test scores. These results suggest the need for additional studies focusing on team outcomes, team cohesion, team size, rotation and other factors as they relate to the effective and efficient performance of TBL teams in health science education.

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[1]Department of Paediatrics, University of Oklahoma College of Medicine, Oklahoma City, Oklahoma, USA
[2]Office of Medical Education, University of Oklahoma College of Medicine, Oklahoma City, Oklahoma, USA
[3]Department of Medicine, Humanities and Public Health Sciences, Pennsylvania State University College of Medicine, Hershey, Pennsylvania, USA
[4]Department of Community Health, Boonshoft School of Medicine, Wright State University, Dayton, Ohio, USA
[5]Department of Psychiatry, University of Texas Southwestern Medical Center, Austin, Texas, USA
[6]Department of Psychiatry, Boonshoft School of Medicine, Wright State University, Dayton, Ohio, USA
[7]Department of Psychiatry, Louisiana State University Health Sciences Center, New Orleans, Louisiana, USA
[8]Medical Education and Health Profession Services, National Board of Medical Examiners (NBME), Philadelphia, Pennsylvania, USA
[9]Programme Development and Special Projects, Assessment Programmes Unit, NBME, Philadelphia, Pennsylvania, USA
[10]Department of Biostatistics and Epidemiology, University of Oklahoma Health Sciences Center, College of Public Health, Oklahoma City, Oklahoma, USA
[11]Department of Psychiatry and Behavioural Sciences, University of Texas Medical Branch, Galveston, Texas, USA
Correspondence: Britta M Thompson, Office of Medical Education, University of Oklahoma College of Medicine, 941 Stanton L Young Boulevard, BSEB 115A, Oklahoma City, Oklahoma 73104, USA. Tel: 00 1 405 271 9333; E-mail: britta-thompson@ouhsc.edu

INTRODUCTION

Medical students are increasingly expected to acquire the knowledge and skills required to effectively function within a team.[1] More than a decade ago, the Institute of Medicine, along with many other health organisations and regulatory bodies, called for a health care workforce able to work effectively in teams.[2]

Team-based learning (TBL) is a structured educational method that requires students to individually learn core factual material prior to class and then to use class time to practise the application of this core material in learning teams.[3,4] Students are assigned to teams; the entire team must collaborate to collectively determine the answers to both factual questions and complex application problems. Details of TBL are outside the scope of this paper, but readers are directed to several overviews.[3–6] Originally designed as a replacement for the lecture, TBL is a teacher-directed method of facilitating multiple small groups in one classroom, usually with a single instructor. Team-based learning moves beyond the acquisition of facts to emphasise the application of session or course content in meaningful real-world scenarios.[6] In health science education, TBL has been associated with increased engagement, increased appreciation of the value of teams, and acquisition of knowledge in a manner that is often superior to that of conventional didactic methods.[7–11]

Team academic performance outcomes associated with TBL

The literature on TBL suggests positive performance outcomes for learners at the individual level. In recent systematic reviews of the TBL literature in health professions education, Fatmi *et al.*[10] and Haidet *et al.*[11] reported improvements in knowledge outcomes in educational studies that compared TBL methods with other educational methods such as the lecture. Some researchers have noted that students in the lowest academic quartiles may benefit most from TBL.[8] To date, the focus of most TBL studies has been the improved performance outcomes of students rather than of teams. Given the emphasis on teamwork within the health care setting, assessing the performance outcomes of TBL teams is an important endeavour.

Variables associated with team performance outcomes

Team cohesion

Team functioning, or team cohesion, reflects the degree to which members are committed to one another in the achievement of team goals. Factors that are purported to contribute to team cohesion include number of team sessions, amount of time in the team, team size, team accountability and rewards for success.[3] Team cohesion is a factor that is related to academic performance outcomes in TBL. Michaelsen *et al.*[3,4] suggest that members of low-cohesion teams are less likely to pull together in high-pressure situations and perform poorly as a team. It has long been purported that TBL activities should promote team cohesiveness because more cohesive teams are associated with better performance outcomes. However, few, if any, studies have tested this assumption in health sciences education.

Team size

Based on literature from the fields of business and education, the optimal size of a TBL team is considered to be five to seven members.[2,3] Large teams are purported to possess the collective intelligence to solve complex classroom problems. Although larger teams have more collective intelligence, smaller teams develop group cohesiveness more quickly, thereby enhancing their initial team performance.[3]

Gender

Within the education and business literature, researchers have shown the value of including both males and females for the demonstration of diverse viewpoints; however, group diversity can initially decrease the cohesiveness of a team.[3] Some studies[12] have indicated that female students rate TBL processes significantly more highly than males and also score more highly on individual readiness assurance tests (iRATs) and final examinations compared with their male counterparts.

The purpose of the present study was to determine the association of variables collected at the individual and team level with team academic performance outcomes of medical student TBL teams. We tested the hypothesis that National Board of Medical Examiners (NBME) test scores and Team Performance Scale (TPS) ratings by individuals within TBL teams, team size and rotations held later in the

year would be positively associated with scores on a team-administered NBME Subject Test and that the male dominance of teams would be negatively associated.

METHODS

To determine the relationships among team size, team gender make-up, rotation, individual NBME Psychiatry Subject Test scores of students within the team and student ratings of the cohesion of the team and academic performance outcomes, the NBME Psychiatry Subject Test was administered to Year three students on a psychiatry rotation at four medical school sites that used TBL. The participating sites included the University of Texas Medical Branch at Galveston, the University of Texas Medical Branch at Austin, Louisiana State Health Science Center and Wright State University Boonshoft School of Medicine during the 2010/2011 and 2011/2012 academic years. Sites were public institutions and the majority (83–98%) of the student populations were in-state residents. All incorporated small-group sessions such as TBL or problem-based learning in the pre-clinical curriculum. All sites delivered content in the psychiatry clerkship using TBL, with a minimum of four TBL sessions. Team-based learning teams in these psychiatry clerkship courses were longitudinal and had stable membership throughout the clerkship. All clerkships were 6 weeks in length and used both individual and team scores to determine final grades for the psychiatry clerkship.

To determine perceptions of TBL team cohesiveness, the TPS[13] was administered to students during the final week of the clerkship. The TPS is an 18-item instrument in which each item is scored on a scale of 0 ('none of the time') to 6 ('all of the time'). All items asked students to rate the behaviour of their team. Items included: 'All team members made an effort to participate in discussions', 'My team actively elicited multiple points of view before deciding on a final answer' and 'Team members seemed attentive to what other team members were saying when they spoke.' Scores on the TPS were analysed by determining a mean score for each student. Cronbach's alpha for the TPS was 0.95. Additional validity and reliability analyses of TPS scores can be found in Thompson *et al.*[13] To determine team-level scores for correlation and regression analyses, we determined the mean individual TPS ratings from members of each TBL team (*mTPS*).

To assess the academic performance of teams, students completed the NBME Psychiatry Subject Test. This test utilises multiple-choice application questions in a single best-answer format, similarly to TBL exercises. According to NBME information, this test evaluates the application of knowledge rather than the recall of isolated facts; the test has evidence of validity and reliability. The test was administered to students first on an individual basis. It was then administered as a team test to the TBL teams. After turning in their individual tests, students were given a 30-minute break between the individual and team NBME examinations, but were required to stay in the proctored environment and were not allowed to discuss the test during the break. Each TBL team then completed the same NBME Psychiatry Subject Test as a team, completing one collective test. Raw NBME test scores, not percentile scores, were used in the analyses for both individual and team tests. To determine team-level scores of NBME tests taken at the individual level for correlation and regression analysis, we calculated the mean of individual NBME scores for each team (*mNBME*).

To determine the influence of other variables on team NBME test scores, we determined the team gender make-up, the team size and the rotation. The gender make-up of each team was determined by calculating the percentage of males within each team (*Gender*). Team size was the total number of students on each TBL team (*Team size*). *Rotation* denoted the point at which each TBL team's clerkship rotation occurred: the first 6-week rotation was coded as '1', the second 6-week rotation was coded as '2' and so on.

We first conducted descriptive analyses of our data. To measure the strength as well as the direction (negative or positive) of the linear relationship between team-level variables, we determined the correlation coefficient between each. We then conducted a multivariable linear regression analysis to assess the effects of the team-level variables on team NBME test scores, taking into account the influence of all variables simultaneously. We used team NBME test scores as the dependent variable and team variables (*mTPS*, *mNBME*, *Team size*, *Rotation* and *Gender*) as the independent variables.

Finally, we used hierarchical linear model (HLM) analysis to assess the effect of individual-level variables (TPS and NBME scores) nested within teams, as well as the effects of team-level variables (*Rotation, Team size, Gender*) on team NBME test scores. Using this statistical method allowed us to incorporate the

variability of individual TPS and NBME scores within each team in the estimation process.[14]

We analysed our data using IBM SPSS STATISTICS for Windows Version 19.0 (IBM Corp., Armonk, NY, USA) and SAS PROC MIXED Version 9.2 (SAS Institute, Inc., Cary, NC, USA) (for HLM). Alpha was set at 0.05. The study was approved by the institutional review boards at each of the participating institutions.

RESULTS

Results on the NBME Psychiatry Subject Test for 991 Year three medical students across four schools were collected for this study. Of these, 975 completed the TPS, for a response rate of 98.4%. These students represented 173 TBL learning teams. Most teams had five to seven members (mean ± standard deviation [SD] 5.77 ± 0.72) based on TBL best practices[2] and the set-ups that were practical at each of the various sites within their courses. Only two teams had four members and one team had eight. The average team was comprised of 57.6% male students (range: 0–100%). The mean ± SD individual NBME test score was 80.36 ± 8.74. The mean ± sd team NBME score was 101.61 ± 3.60. The mean ± SD TPS rating of all students was 5.30 ± 0.39.

We first correlated the team NBME scores with *mTPS*, *mNBME*, *Team size*, *Rotation* and *Gender*. We noted that team NBME scores were significantly negatively correlated with *mTPS* and significantly positively correlated with *mNBME* scores and *Team size* (Table 1).

Multivariable linear regression analysis indicated that the combination of team-level variables (*mTPS*, *mNBME*, *Team size*, *Rotation* and *Gender*) significantly predicted team NBME scores. The beta weights of each variable are presented in Table 2. These data show that *mNBME* and *Team size* statistically significantly and positively contributed to the prediction of team NBME scores. *Rotation* was a positive predictor, *mTPS* and *Gender* were negative predictors but these were not statistically significant predictors. The adjusted R^2 for the model was 0.42.

Finally, we analysed our data using HLMs, nesting students within teams. At the individual level, we used individual NBME test scores and individual TPS scores by students within each team. At the team level, we used *Team size*, *Rotation* and *Gender*. Our model had an R^2-value of 0.997, which was a much better fit than that of the model without the nested terms (R^2 = 0.16). Interestingly, our analysis of students nested within teams showed that the estimated effects of both individual NBME test scores and individual TPS scores were positively (and statistically significantly) associated with team NBME test scores (Table 3). Our analysis also indicated that several team-level variables were significantly associated with team NBME test scores. Larger team size was associated with higher team NBME test scores. Specifically, for every additional person on a team, team NBME test scores were estimated to increase by 0.84 points on average ($p < 0.01$). As expected, teams that were part of psychiatry clerkship rotations that occurred earlier in the year were associated with lower team NBME test scores, generally disadvantaging early rotations by as much as 2.80 points, with the exception of

Table 1 Correlation coefficients of team-level variables with team National Board of Medical Examiners (NBME) Psychiatry Subject Test scores in 173 team-based learning (TBL) teams at four medical schools

	Team NBME	mTPS	mNBME	Team size	Rotation	Gender
Team NBME	1					
mTPS	−0.20*	1				
mNBME	0.62*	−0.14	1			
Team size	0.28*	−0.23*	0.12	1		
Rotation	0.14	−0.09	0.16†	< −0.01	1	
Gender	0.02	−0.13	0.01	0.15	0.10	1

mNBME = *mean of individual NBME scores for each team;* mTPS = *mean individual Team Performance Scale ratings from members of each TBL team.*
*Correlation is significant at $p < 0.01$.
†Correlation is significant at $p < 0.05$.

*Table 2 Regression analyses of predictors (*mTPS, mNBME, Team size, Gender, Rotation*) on the dependent variable team National Board of Medical Examiners (NBME) Psychiatry Subject Test in 173 team-based learning (TBL) teams at four medical schools*

	Unstandardised β	SE	Standardised β	t	p-Value
(Constant)	61.48	5.54		11.11	< 0.01
Rotation	0.08	0.09	0.05	0.82	0.41
Gender	−0.01	0.01	−0.03	−0.47	0.64
Team size	0.98	0.30	0.20	3.22	< 0.01
mNBME	0.47	0.05	0.58	9.66	< 0.01
mTPS	−0.64	0.56	−0.07	−1.16	0.25

mNBME = *mean of individual NBME scores for each team;* mTPS = *mean individual Team Performance Scale ratings from members of each TBL team.*

rotation 6. The gender make-up of the teams was not significantly associated with team NBME test scores. Table 3 provides statistics for individual and team-level variables from the HLM analysis.

DISCUSSION

For this study, we evaluated the associations among individual student scores on a high-stakes test (the NBME Psychiatry Subject Test), student ratings of the cohesiveness of each of the respective teams (using the TPS), team size, team gender make-up, and timing of the rotation on team NBME test scores. Results using correlation, multivariable linear regression and HLM analyses indicated that team characteristics influenced the academic performance of teams in TBL. Using all three analyses, we noted that larger TBL teams scored more highly on the team NBME test. Hierarchical linear modelling indicated that each additional person on a TBL team resulted in almost a point increase in team NBME test scores. All three analyses also indicated that *Rotation* was positively associated with team NBME test scores; however, only HLM indicated that this relationship was statistically significant. Teams that rotated earlier in the year tended to score about 1 to almost 3 points lower on the team test, with the exception of those on rotation 6, using HLM analysis. We are unsure why teams on rotation 6 scored lower as a whole.

Our results illustrate how various statistical analyses can influence the results of data collected within teams. Whereas NBME test scores (*mNBME*) of students demonstrated a statistically significant and positive relationship with team NBME test scores, regardless of analysis method, the results on team

Table 3 Hierarchical linear modelling analysis of individual-level and team-level covariates with team National Board of Medical Examiners (NBME) Psychiatry Subject Test score as the dependent variable in 173 team-based learning teams at four medical schools

Source	d.f.	Type III SS	Mean square	F-*value*	p-Value
Team-level variables					
Rotation	7	3.82	0.55	13.93	< 0.01
Size	1	0.97	0.98	24.95	< 0.01
Gender	1	0.03	0.03	0.86	0.35
Individual-level variables (nested within teams)					
Individual TPS	172	50.21	0.29	7.44	< 0.01
Individual NBME	172	90.81	0.53	13.46	< 0.01

TPS = Team Performance Scale.

cohesion (TPS scores) were strongly influenced by the analysis used. Correlation and multivariate linear regression analyses of individual TPS scores aggregated at the team level (*mTPS*) had a *negative* association with team NBME test scores, with correlation analysis indicating a statistically significant but weak relationship. However, HLM analysis indicated that individual TPS scores (nested within teams) represented a statistically significant and *positive* predictor of team NBME test performance.

We were surprised at the differences in the results we obtained using various analysis methods. For the correlation and regression analyses, we analysed the individual TPS scores of each team member condensed into a mean score for each team. This prevented us from accounting for the variation in individual scores within teams. Other articles have shown similar outcomes, indicating that multivariable linear analysis can underestimate the effects of some variables and overestimate the effects of others, especially those collected at the individual level.[15] For our study, we feel that HLM more appropriately allowed us to account for variation in individual TPS scores within each of the teams. This variation in individual TPS scores indicated that team cohesion was a significant and positive predictor of team NBME test performance.

Our results support the proposal of Michaelsen *et al.*[2], who suggest that teams must be large enough to ensure an adequate intellectual pool for successful team performance. Our HLM suggested that the NBME test scores of individuals within the teams represented a significant variable, as did the number of students on each team.

One limitation of the present study concerns the limited variability in the size of teams. Team size was based on best practice recommendations[2,3] and feasibility and flexibility at each of the sites. We included only one team with more than seven students and only two teams with fewer than five students. Interestingly, in a recent study, Swaab *et al.*[16] suggested a 'too-much-talent' effect within teams. This effect occurs when too many dominant and high-functioning individuals jostle for alpha rank within a team, which diminishes team cohesion. Studies in poultry science have shown that housing too many high egg-producing hens together actually decreases egg production because the hens spend unnecessary time trying to peck their way to the top of the group. Similarly, the number of superstars on an interdependent team in a sport such as football or basketball (unlike those in more individual sports such as baseball) benefit performance and cohesion up to a point, at which cohesion and performance actually diminish. Because most of our teams consisted of five to seven individuals, we were limited in our ability to study how large is too large (or how small is too small). However, it was clear from our data that team size was a significant predictor of team performance. Additional studies with larger variability in team size (more than four and fewer than seven members) may further determine the optimal TBL team size in health science education.

Team cohesion has been emphasised as an important part of the TBL team process. Michaelsen *et al.*[4] suggest that a minimum of 20–25 hours of TBL is required before members fully access and benefit from the resources of all members of the group. Likewise, research in the area of psychotherapy suggests that at least 12 sessions are required for cohesion to have the strongest relationship to outcomes.[17] Our results were based on a limited number of TBL sessions. Future studies involving varied numbers of TBL sessions or studies involving comparison schools not utilising TBL teams may help to further elucidate if there is a dosage-related effect in these results.

Our study had several limitations. Firstly, the TPS and team NBME Subject Test administered at the end of the course showed a ceiling effect: most of the teams scored at the 99th percentile on the team NBME test (and were re-scored as raw scores), and most students rated their teams as cohesive. In a sense, this may speak of the success of the TBL method that was implemented at the four sites. An alternative explanation is that the team NBME test results reflected a test–retest effect. Although we cannot rule out this explanation because we did not have a control group that took the team test only (without students first taking the test individually), this would seem unlikely because we did not show students their initial test scores and thus they did not know how they had performed. In addition, the tests were administered only 30 minutes apart in time and therefore the students had no opportunity to consolidate information or to benefit from the initial testing.

Although our study included almost 1000 students and 173 teams, it was limited to students at four medical school sites running 6-week psychiatry clerkships. We cannot assume that our results can be generalised to other teams in health science education or the health care setting, such as clinical or interprofessional teams. However, our results are

intriguing and provide a foundation for other studies regarding team variables and team academic performance.

Our study is one of the first to explore team academic performance outcomes of TBL teams and the estimated effects of variables at not only the team level, but also at the level of individuals within teams. Our results of the administration of an NBME Psychiatry Subject Test to TBL teams at four medical schools suggested that variables that were positively and significantly associated with team NBME scores included larger teams and teams that rotated later in the year. At the individual level, individual NBME test scores and team cohesion ratings were significantly associated with higher team NBME test scores. Our study suggests the need for additional studies in the areas of team outcomes, team cohesion, team size and other factors as they relate to the effective and efficient performance of TBL teams in health sciences education. Our results provide additional information regarding various practices used in TBL, such as the influence of team size, intellectual ability of team members, cohesiveness of team, and timing of rotation on team grades.

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