INTRODUCTION

Team-based learning (TBL) is a learner’s centered teaching method, which enables the students to apply conceptual knowledge by performing a set of activities that include preclass preparation, individual and group activities followed by application exercises and immediate feedback.[1] TBL has gained popularity in recent years as an instructional design which effectively engages the students in an active class and fosters critical thinking.[2]

TBL has been used widely in nursing education. Studies in undergraduate nursing students have shown that TBL enhances levels of engagement and improves academic performance, especially in lower achieving students.[3] High levels of student satisfaction in areas of quality of learning, team work experience, clinical reasoning, and professional development are also associated with TBL in undergraduate nursing students.[4] Deep and satisfying learning experiences with TBL in nursing students are also shown to be associated with increased confidence in the provision of safe patient care.[5] TBL is shown to improve the problem-solving skills and clinical performance in nursing students.[6]

The essential components of TBL can be summarized in three stages. In the first stage, which is the “advance preparation”
stage, the students are required to complete learning tasks before the class. In the second stage, which is the “readiness assurance” stage, the students are required to undergo individual and group testing during the class time. The third stage, which is referred to as the “application of core concepts” stage, the students are challenged with application exercises.[6-8]

The aforementioned studies indicate that TBL is a popular instructional technique in undergraduate university education. It has enticed some instructors to a point where they proceeded to design and test modified versions of TBL. Instructors have combined TBL with audience response system and presented it as a new instructional strategy.[9,10]

On the other hand, some instructors used pretest concept revision using integrative cases with TBL,[11] whereas others allowed free use of handout materials in the “readiness assurance” stage.[12] Instructors also combined the use of course management systems such as Moodle or Blackboard Learn with TBL.[13,14]

In the present study, TBL is combined with high fidelity simulation. High fidelity simulation is increasingly used to enhance clinical practice, teach patient safety, and improve clinical judgment skills in nursing students.[15] High fidelity simulation offers a customized and safe environment of learning to the nursing students who are able to build confidence in patient care because due to ready familiarization with clinical situations.[16] Both TBL and high fidelity simulation are collaborative techniques which improve critical thinking skills and prepare students for their future roles in patient care in clinical settings.[1,17-19] Therefore, it can be hypothesized that combination of the two techniques, TBL with high fidelity simulation (TBL-high flood level [HFL]), will have positive outcomes on test performance and attitude toward TBL in undergraduate nursing students.

The purpose of this study was to assess student’s test performance and attitude with TBL with high fidelity simulation model (TBL-HFL) and conventional TBL (CTBL) model and offer a comparison.

METHODS

The study was conducted in King Saud bin Abdulaziz University for Health Sciences located in the western region. The design selected for this study was the two-group (posttest only) experimental design. Owing to randomization, the two groups were assumed to be probabilistically equivalent. The ethical approval of the study (Approval No: H-01-R-005) was received from the Research Office at King Abdullah International Medical Research Center. Before the data collection, informed consent form was signed by each participant of the study. Data of the students refusing participation were excluded from the analysis. The students (n = 81) included in the study were enrolled in pediatric nursing course at the College of Nursing in the university. They were assigned into two groups (sections) by a random computer generated allocation system, by the academic office, at the time of registration in the course.

Five topics from the course were selected to be conducted by TBL in both groups. The learning outcomes in both the groups were same. In Group 1, the CTBL model was used which comprised of (a) preclass preparation, (b) individual readiness assurance test (IRAT), (c) group readiness assurance test (GRAT), and (d) case study-based application exercise. In the Group 2, TBL was combined with high fidelity simulation in the application exercise phase. The activities in Group 2 included (a) preclass preparation, (b) IRAT, (c) GRAT, and (d) application exercise comprising of case scenario with high fidelity simulation. Laerdal SimBaby was used for the high fidelity simulation activity which is a high-tech mannequin. SimBaby can be used to simulate working with a 6–12 months old child. It is optimized with required features for the airway, circulation, CPR, optic, vocal, etc., One example of the scenarios was “Unstable tachycardia poor perfusion” in a 10-month-old infant who ingested an unknown quantity of mother’s medication. Scenario planning worksheets were prepared before the activity with time specifications for scenario and debriefing. Learning outcomes, cognitive and psychomotor skills, proposed correct treatment outline and required checklists (e.g., equipment and setup) were defined. Laerdal Sim Software © 2019 Laerdal Medical was used to edit and label the scenario, customize patient description and menu, edit event menu, create and connect frames and trends and create an event handler.

Similar preclass learning content was uploaded on Blackboard Learn system, which is an E-Learning Software, © 1997-2020 Blackboard Inc. U.S. Patent No. 7,493,396 and 7,558,853. After completion of the course, the students were asked to complete a 13-item questionnaire that measured their attitude toward TBL. The questionnaire was a five-point Likert type scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). The questionnaire was developed by the author of the study based on similar studies. It was submitted to three experts in the medical education department for face validity and their suggestions were incorporated. It was pretested in 30 participants and the Cronbach’s alpha value was 0.87.

Both the groups completed a test comprising of 30 knowledge-based items and 60 cognitive assessment items. SPSS version 20© Copyright IBM Corporation 2017 was used for data analysis. The data were normally distributed. The test scores between the two groups were compared. The difference between the mean values of the test scores across the two groups (Group 1 and Group 2) was analyzed by paired sample t-test. P < 0.05 was considered statistically
significant. The mean values of responses for each item in the questionnaire between the two groups were compared by Independent sample t-test.

RESULTS

All participants in the study were female, and their mean age was 20.65 ± 1.02. All of them had access to the preclass learning assignment generated on the online E-Learning System (Blackboard Learn®). Table 1 shows the difference in the test scores of the students between the two groups. A significant difference (P < 0.001) is shown in the test scores of cognitive test items.

Table 2 indicates the difference between the responses of Group 1 and Group 2 for each item in the questionnaire that measured the student’s attitude toward TBL. The mean score of the students in Group 1 (2.868 ± 0.85) was less than the mean score of the students in Group 2 (3.13 ± 0.85).

DISCUSSION

The present study was designed to compare the effects of “CTBL” and “TBL combined with high fidelity simulation” on test performance and attitude toward TBL in undergraduate nursing students. Students in Group 1 covered the learning tasks with CTBL, whereas the students in Group 2 covered similar learning tasks with TBL combined with high fidelity simulation.

Table 1: Difference between the test scores of Group 1 and Group 2

| Assessment domains                  | Mean percentile scores of test items | Group 1   | Group 2   | t     | P     |
|-------------------------------------|--------------------------------------|-----------|-----------|-------|-------|
| Knowledge and recall test items     | 76.37±18.90                          | 74.81±18  | 0.45      | 0.66  |
| Cognitive test items                | 65.31±20.02                          | 83.71±14.23 | -5.54    | <0.001|
| Total test score                    | 69±20.24                             | 80.74±16.04 | -4.38    | <0.001|

The findings indicate that the test performance of students in Group 2 was better than Group 1 in cognitive assessment domain, which tested their analytical and application skills. Previous studies have indicated that high fidelity simulation enhances scores in skills and knowledge exam.[20] In the present study, it is revealed that using high fidelity simulation in application phase of TBL has a synergistic effect, and it can be used to improve test scores. The result depicted in the present study that involved a pediatric nursing course is also supported by another research conducted in Taiwan, showing significant improvements in pediatric technical skills in the students after high fidelity simulation training.[21]

Table 1 shows that although the difference in the test scores of cognitive items was significant, the overall test scores also favored the group with high fidelity simulation. It is an important finding because research was required to generate evidence validating the effectiveness of simulation in pediatric nursing education and practice, especially in the context of technical, cognitive, and psychomotor skills.[22] Another study on the challenges in pediatric nursing education identified a major barrier which was presented as “competition for clinical practice sites” in up to 76% of nursing educational programs.[23] TBL combined with high fidelity simulation, is, therefore, an effective solution because it offers a safe and effective learning environment, which can be tailored according to the learning needs of the students and closely mimics the clinical practice site.

Table 2 compares the attitude of the two groups toward TBL. Although the overall mean score of the responses in Group 1 was slightly higher than the cutoff point of the scale (2.5), the results were more pronounced in responses from Group 2. A higher mean score indicative of a more positive attitude toward TBL was noted in Group 2. The first seven statements of the questionnaire measured student’s attitude particularly toward the effectiveness of the application exercise. Although a significant difference was not noted in responses between the two groups regarding their self-perceived responsibility.

Table 2: Comparison between Group 1 and Group 2 regarding individual attitude toward team-based learning

| Item                          | Statement                                                                 | Mean±SD   | df  | t     | P     |
|-------------------------------|---------------------------------------------------------------------------|-----------|-----|-------|-------|
| 1                             | My preclass learning was most useful in application exercise             | 2.58±1.06 | 79  | -4.38 | <0.001* |
| 2                             | Individual brain storming during IRAT was most useful in application exercise | 3.32±0.77 | 79  | -2.41 | 0.018* |
| 3                             | Group discussion during GRAT was most useful in application exercise      | 2.63±0.79 | 78  | -3.72 | <0.001* |
| 4                             | Support from team members was most useful in application exercise         | 2.66±0.91 | 79  | -2.10 | 0.039* |
| 5                             | The application exercise was enjoyable                                   | 2.45±0.86 | 79  | -3.95 | <0.001* |
| 6                             | I felt more responsible about my learning during application exercise     | 2.76±0.82 | 79  | 0.23  | 0.815  |
| 7                             | I could easily remember concepts acquired in application exercise during tests | 2.58±0.98 | 79  | -3.20 | 0.002* |
| 8                             | I am aware about the learning needs of my team members during TBL        | 2.71±1.01 | 79  | -2.0  | 0.048* |
| 9                             | I give valuable input during group discussion in TBL                     | 2.79±0.87 | 79  | -1.23 | 0.221  |
| 10                            | Support from the teacher was very effective during TBL                   | 3.76±0.71 | 79  | 0.27  | 0.789  |
| 11                            | I can more easily remember material from lectures than TBL               | 2.58±0.72 | 79  | 0.56  | 0.579  |
| 12                            | I can easily apply knowledge acquired during application exercise in clinical settings | 3.13±0.84 | 79  | 0.44  | 0.658  |
| 13                            | I feel that all team members contribute equally in the learning process.  | 3.34±0.78 | 73  | 3.98  | <0.001* |

TBL: Team-based learning, SD: Standard deviation, IRAT: Individual readiness assurance test, GRAT: Group readiness assurance test, *: Highly significant
toward self-learning in application exercise, there were statistically significant differences for each one the other six items. Students in Group 2 had more positive responses regarding the utility of preclass preparation, IRAT and GRAT in effective execution of learning tasks in the application phase and the difference between the two groups was highly significant. Students in Group 2 also showed a more positive attitude toward anticipated support from peers and had a more enjoyable experience in the application phase with high fidelity simulation. Previous studies have shown that emotions of joy in the learning process impact the interest and performance of the students.\textsuperscript{24,25} In a similar context, findings in the present study have shown that a positive attitude of Group 2 toward enjoyment in TBL is coupled with better test performance.

Table 2 further shows that the students in Group 2 had a more conscious attitude toward the learning needs of their peers. They also had a more positive attitude toward their ability to recall concepts during tests. These results indicate a higher order of thinking in the students in Group 2. It has been previously shown that higher order thinking skills are improved in technologically enhanced learning environment.\textsuperscript{26} In the present study, the technology rich learning environment was facilitated by the use of the high fidelity simulation manikins. Table 2 indicates that the student’s attitude toward instructor support, own contribution toward learning process, preference over didactic lectures, and confidence regarding clinical performance was not significantly different across the two groups.

In summary, better test scores in students in Group 2 indicate that high fidelity simulation coupled with TBL enhances academic achievement in undergraduate nursing students. This finding supports previous studies showing a significant improvement in test performance of nursing students taught with TBL\textsuperscript{27} and high fidelity simulation.\textsuperscript{20,21} Students were able to solve case studies in examinations because the addition of high fidelity simulation in TBL, sharpened their critical thinking and clinical reasoning skills. Sharpening of clinical reasoning skills with subsequent improvement is test performance is similarly reported in medical students.\textsuperscript{28} The enjoyed learning experience in Group 2, reported in this study is in line with similar observations made in an earlier study, showing that high fidelity simulation reduces anxiety in pediatric nursing students and allows them to experience joy of learning.\textsuperscript{29}

This study has some limitations. One of the limitations is the small sample size. Furthermore, it is a single institution study, and all students included in this study are female. For further research, longitudinal study designs and data site triangulation are recommended. Future research is recommended to study the effectiveness of TBL with high fidelity simulation on the knowledge retention and application skills of nursing interns. Studies on TBL with high fidelity simulation in inter-professional education may offer valuable insights into the phenomenon.

**CONCLUSION**

TBL combined with high fidelity simulation has improved test scores in undergraduate nursing students in pediatric nursing course. Test performance of students who completed high fidelity simulation application exercise was better than the group of students who solved case studies during TBL application phase in class. The students in high fidelity simulation group had a more enjoyable experience during the application phase and a more positive overall attitude toward TBL.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Parmelee D, Michaelsen LK, Cook S, Hudes PD. Team-based learning: A practical guide: AMEE guide no. 65. Med Teach 2012;34:e275-87.
2. Parmelee DX, Michaelsen LK. Twelve tips for doing effective Team-Based Learning (TBL). Med Teach 2010;32:118-22.
3. Dearnley C, Rhodes C, Roberts P, Williams P, Prenton S. Team based learning in nursing and midwifery higher education; a systematic review of the evidence for change. Nurse Educ Today 2018;60:75-83.
4. Wong AK, Wong FK, Chan HK, Chan N, Ganotice FA, Ho J. The effect of interprofessional team-based learning among nursing students: A quasi-experimental study. Nurse Educ Today 2017;53:13-8.
5. Currey J, Eustace P, Oldland E, Glanville D, Story I. Developing professional attributes in critical care nurses using Team-Based Learning. Nurse Educ Pract 2015;15:232-8.
6. Kim HR, Song Y, Lindquist R, Kang HY. Effects of team-based learning on problem-solving, knowledge and clinical performance of Korean nursing students. Nurse Educ Today 2016;38:115-8.
7. Parmelee DX, Hudes P. Team-based learning: A relevant strategy in health professionals’ education. Med Teach 2012;34:411-3.
8. Clark MC, Nguyen HT, Bray C, Levine RE. Team-based learning in an undergraduate nursing course. J Nurs Educ 2008;47:111-7.
9. Pileggi R, O’Neill PN. Team-based learning using an audience response system: An innovative method of teaching diagnosis to undergraduate dental students. J Dent Educ 2008;72:1182-8.
10. Fujikura T, Takeshita T, Honma H, Adachi K, Miyake K, Kudo M, et al. Team-based learning using an audience response system: A possible new strategy for interactive medical education. J Nippon Med Sch 2013;80:63-9.
11. Persky AM, Pollack GM. A modified team-based learning physiology course. Am J Pharm Educ 2011;75:204.
12. Shankar N, Roopa R. Evaluation of a modified team based learning method for teaching general embryology to 1st year medical graduate students. Indian J Med Sci 2009;63:4-12.
13. Gopalan C, Khanna MC. The effect of flipped teaching combined with modified team-based learning on student performance in physiology. Adv Physiol Educ 2017;41:363-7.
14. Bano N, de Beer J, Omer TY. Team-based learning in postgraduate midwifery education: A descriptive qualitative study. Educ Health Prof 2019;2:98-102.
15. Smith SJ, Roehrs CJ. High-fidelity simulation: Factors correlated with nursing student satisfaction and self-confidence. Nurs Educ Perspect 2009;30:74-8.
16. Weaver A. High-fidelity patient simulation in nursing education: An integrative review. Nurs Educ Perspect 2011;32:37-40.
17. Bradley C. The role of high-fidelity clinical simulation in teaching and learning in the health professions. Higher Educ Res Network J 2011;4:33-42.
18. Hyland JR, Hawkins MC. High-fidelity human simulation in nursing education: A review of literature and guide for implementation. Teach Learn Nurs 2009;4:14-21.
19. Thompson BM, Schneider VF, Haidet P, Levine RE, McMahon KK, Perkowski LC, et al. Team-based learning at ten medical schools: Two years later. Med Educ 2007;41:250-7.
20. Yuan HB, Williams BA, Fang JB, Ye QH. A systematic review of selected evidence on improving knowledge and skills through high-fidelity simulation. Nurse Educ Today 2012;32:294-8.
21. Tsai TC, Harasym PH, Nijssen-Jordan C, Jennett P. Learning gains derived from a high-fidelity mannequin-based simulation in the pediatric emergency department. J Formos Med Assoc 2006;105:94-8.
22. Broussard L, Myers R, Lemoine J. Preparing pediatric nurses: The role of simulation-based learning. Issues Compr Pediatr Nurs 2009;32:4-15.
23. McCarthy AM, Wyatt JS. Undergraduate pediatric nursing education: Issues, challenges and recommendations. J Prof Nurs 2014;30:130-8.
24. Schukajlow S, Rakoczy K. The power of emotions: Can enjoyment and boredom explain the impact of individual preconditions and teaching methods on interest and performance in mathematics? Learn Instr 2016;44:117-27.
25. Subhash S, Cudney EA. Gamified learning in higher education: A systematic review of the literature. Comput Human Behav 2018;87:192-206.
26. Hopson MH, Simms RL, Knezek GA. Using a technology-enriched environment to improve higher-order thinking skills. J Res Technol Educ 2001;34:109-19.
27. El-Banna MM, Whitlow M, McNelis AM. Improving pharmacology standardized test and final examination scores through team-based learning. Nurse Educ 2020;45:47-50.
28. Mutter MK, Martindale JR, Shah N, Gusic ME, Wolf SJ. Case-based teaching: Does the addition of high-fidelity simulation make a difference in medical students’ clinical reasoning skills? Med Sci Educ 2020;10:1-7.
29. Megel ME, Black J, Clark L, Carstens P, Jenkins LD, Promes J, et al. Effect of high-fidelity simulation on pediatric nursing students’ anxiety. Clin Simul Nurs 2012;8:e419-28.