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The Effect of Team-Based Learning in a Neurorehabilitation Course within a Physical Therapist Assistant Academic Program

Laurie A Schroder [1]***, Lori Kupczynski*** [2]**** and Shannon L Groff*** [3]

University of St. Augustine for Health Sciences [1]***, Texas A&M University-Kingsville*** [2]**** and Florida College at Jacksonville*** [3]***, USA***
capitola16@yahoo.com*

Abstract: *Physical therapist assistant (PTA) education is a rigorous process that includes difficult courses and high standards for academic progression. PTA programs have a nearly 20% attrition rate, which is costly for students, programs, and institutions. The aim of this study was to determine whether learning outcomes in a neurorehabilitation course were improved when the course was presented using team-based learning (TBL). This study used a quantitative, quasi-experimental, ex post facto design to examine the effectiveness of team-based learning. Team-based learning is reported to encourage the development of self-efficacy, self-directed learning, and team skills; however, it is unclear whether it also results in increased student achievement of learning outcomes. To this end, the research questions for this study asked whether students who participated in a neurorehabilitation course would demonstrate higher learning outcomes on in-class examinations and/or on the National Physical Therapy Examination-Physical Therapist Assistant (NPTE-PTA) as compared to students who participated in the same course in a lecture-based format. These questions were answered through the assessment of learning outcomes for two groups of students enrolled in the course in non-consecutive years. Analysis indicates that there was no significant difference in examination or NPTE-PTA Neuromuscular and Neurological Systems scores between the two groups while controlling for pre-course grade point average (GPA). Consequently, TBL appears to be at least as effective as lecture-based instruction in achieving student learning outcomes. Further research could be undertaken to identify when during a program TBL is most efficacious and whether reported benefits unrelated to learning outcomes warrant inclusion of TBL in PTA education.*

Keywords: Active Learning; PTA; TBL; effectiveness; quantitative; lecture; teaching and learning.

Introduction

Physical therapist assistant (PTA) education is a rigorous process that results in the graduation and licensure of entry-level generalist practitioners who work under the supervision of physical therapists. Although the majority of PTA programs utilize selection criteria in an attempt to secure capable students, graduation rates range from 41.7% - 100%

for all programs accredited by the Commission on Accreditation in Physical Therapy Education (CAPTE). The average graduation rate is 81% (American Physical Therapy Association, 2015a). Attrition from PTA programs is primarily due to academic issues (Desmarais, Woble-Valenski, and Oestmann, 2011).

The length of a PTA program is typically two full years, and consists of general education, technical coursework, and clinical education. The curriculum that must be mastered over the course of a program is inclusive of fifty-one interventions, tests, and measures dictated by the Standards and Required Elements for Accreditation of Physical Therapist Assistant Education Programs (Commission on Accreditation in Physical Therapy Education, 2016). Training in these skills is founded on courses in general education that include written communication and biological, physical, behavioral and social sciences. Among courses required in medical and allied health education, including PTA education, those related to the neurosciences are some of the most difficult (Anwar, Shaikh, Sajid, Cahusac, Alarifi, & Al Shedoukhy, 2015). The fear that students feel when approaching neurological courses has been labeled "neurophobia," and has been demonstrated to continue into practice (Anwar et al., 2015; Maslakpak, Parizad, & Zareie, 2015).

Flanagan, Walsh, and Tubridy (2007) suggested that the difficulties that medical students and doctors have in dealing with patients with neurological problems is due to perceptions that neurology is difficult, merely diagnostic, and that teaching of the subject is not done well. Delivered by lecture methods, difficult material is likely to be lost quickly, and students can develop anxiety, dislike, and eventual disinterest in the subject, and, according to Maranhao-Filho (2014) "a lack of student integration of basic science and clinical information into a cohesive whole" (p. 743). Without deeper learning of neurological principles, students are unlikely to recall and apply those principles in clinical practice after graduating (Flanagan et al., 2007).

A survey of medical students and doctors indicated that they felt their knowledge in neurology was limited, their confidence in assessing patients with neurological problems was lowest of all specialties, and they had received insufficient neurological teaching and limited exposure to neurological patients (Flanagan et al., 2007; Zinchuk, Flanagan, Tubridy, Miller, & McCullough, 2010). Youssef (2009) argues that medical students who identified neurology as the subject they found most difficult and had least knowledge of suggested that greater clinical and practical exposure, more time spent on the subject, and improved teaching skills were needed to improve teaching of neurology.

Multiple changes have been made to medical training in neurology in the past decade (Humbert & Chang, 2014; Maranhao-Filho, 2014; McColgan, McKeown, Selai, Doherty-Allan, & McCarron, 2013). Many medical schools are integrating the neurological sciences into interdisciplinary courses, and methods of instruction are changing from lecture-based to small-group, problem-based learning formats (Galetta, Jozefowicz, & Avitzur, 2006). The Academy of Neurological Physical Therapy has made recommendations for similar curricular changes in physical therapy education (Academy of Neurologic Physical Therapy, 2015).

According to Maslakpak, Parizad, and Zareie (2015), when a great deal of material is delivered via lecture format, students tend to disengage from the material and resort to rote memorization. Additionally, lecture alone tends to limit students' participation and engagement with material, resulting in poor student concentration, which reduces students' absorption of information, knowledge stability and recall of topics. Traditional, passive, lecture-based learning often leads to unsatisfactory learning outcomes due to limited student interaction and a lack of motivation to engage in deeper, self-regulated study (Maslakpak et al., 2015; Yang, Jiang, Xu, Liu, & Liang, 2014). The importance of neurorehabilitation principles necessitates teaching through a more engaging approach (McColgan et al., 2013) as these principles are essential to the successful treatment of patients and clients for physical therapist assistants as they are to members of other healthcare fields (Rathner & Byrne, 2014).

Active learning, defined as "activities introduced into traditional lecture that promote student engagement" (Prince, 2004, p. 1), can improve recall of information and student engagement with material. Hake (1998) examined data for over 6,000 introductory physics students in an effort to identify the efficacy of active learning to improve student engagement and success in a difficult subject. Test scores measuring conceptual understanding were approximately twice as high in classes using active learning than in traditional, lecture-based courses (Prince, 2004).

Lecture-based instruction, as well as curricular designs encompassing active learning, are used in physical therapy education. Active learning models include problem-based learning (PBL), flipped classroom models, skill laboratories and simulation, and demonstration. Of these, lecture-based, demonstration, and problem-based learning remain the most popular; with problem-based learning being the most frequently used active learning strategy (Zaidi & Nasir, 2014). Many of the strengths of problem-based learning reside in its cooperative and collaborative structure, wherein students work together to generate solutions to a given problem, generate hypotheses, discover new knowledge, debate and discuss, and arrive at decisions that solve the problem. However, PBL is extremely resource intensive, requiring one facilitator for every group of ten students (Burgess, Ayton, & Mellis, 2016). Team-based learning (TBL), a cooperative and collaborative instructional strategy developed by Larry Michaelsen, incorporates the strengths of PBL while mediating its challenges (Michaelsen, Bauman Knight, & Fink, 2004). Differences between PBL and TBL stem primarily from the development of effective and self-managed teams, which is critical for TBL. Once these teams are created, one teacher can easily manage a large classroom (Michaelsen, Davidson, & Howell, 2014).

Studies regarding the use of TBL have been completed in many different types of courses; however, studies related to material taught in physical therapy have been limited to gross anatomy (Livingston, Lundy, & Harrington, 2014). Tan, Kandiah, Chan, Umapathi, Lee, and Tan (2011) concludes a study that aimed to determine if TBL was more effective than passive learning in improving outcomes in two key neurology topics for medical students –

neurological localization and neurological emergencies – but the use of TBL for teaching neurological topics to physical therapist or physical therapist assistant students has not been studied (Tan et al., 2011).

Regardless of the discipline studied, establishing the efficacy of TBL has been difficult because of the various designs that have been used when comparing TBL to other instructional methods. For example, most studies have used one or two units within a course as a comparator to traditional instructional methods, versus the use of a complete TBL course compared to a complete course delivered utilizing traditional methods (Altintas, Altintas, & Caglar, 2014). Random assignment of students to a TBL or traditional methods' course has only been used in a few studies (Koles, Nelson, Stolfi, Parmelee, & Destephen, 2005; Thomas & Bowen, 2011). And researchers have used measures that may not correlate directly to achievement of student learning outcomes. Effects measured have typically included student satisfaction, faculty satisfaction, and student engagement (Currey, Oldland, Considine, Glanville, & Story, 2015; Ku, Tseng, & Akarasriworn, 2013; Livingston et al., 2014; Roh, Lee, & Mennenga, 2014). Less often, measures included in-class examination scores. Only in one study, by Tan et al. (2011), was data collected beyond the end of the course to evaluate student retention of important content (Cheng, Liou, Tsai, & Chang, 2014; Maslakpak et al., 2015; Mennenga, 2013; Tan et al., 2011).

Following a systematic review of available TBL literature, Sisk (2011) concluded that, "despite limitations of the studies focusing on examination scores, results have demonstrated that TBL is a promising instructional method. Further research using consistent measurements of student learning would confirm whether TBL should be more widely used" (p.668). Generalizability of current studies of TBL is also limited by the studies' lack of control groups, modifications in TBL design and/or delivery, and the use of group assignment that allowed for exposure of different groups to different levels of previous learning. For example, Bleske, Remington, Wells, Dorsch, Guthrie, Stumpf, Alaniz, Ellingrod, and Tingen (2014) compared examination performance between second-year and third-year pharmacy students, a study design that allowed for comparison of knowledge demonstration on the same content, but with different levels of prior knowledge.

Purpose of the Study

The purpose of this study was to compare the effectiveness of team-based learning (TBL) with traditional teacher-led, lecture-based learning, on learning outcomes in a neurorehabilitation course. This study was completed with second-year physical therapist assistant students enrolled in a two-year physical therapist assistant program in a small, proprietary college in Middle Tennessee. The study measured learning outcomes during the course, as evidenced by in-course examination scores, and learning outcomes in neuroscience overall as evidenced by scores on the Neuromuscular and Neurological System sections of the National Physical Therapy Examination – Physical Therapist Assistant (NPTE-PTA) taken by students following graduation.

Problem Statement

Previous research of the application of TBL has focused primarily on student satisfaction with the TBL process, faculty satisfaction, and student interest, time on task, and/or self-reported engagement. Many authors have shown an increased level of student engagement as well as student and faculty satisfaction (Altintas et al., 2014; Burgess et al., 2016; Clark, Nguyen, Bray, & Levine, 2008; Currey et al., 2015; Haidet, Kubitz, & McCormack, 2014; Mennenga, 2010, 2013; Roh et al., 2014; Sisk, 2011). However, student and faculty satisfaction, or even student engagement, are not necessarily indicative of improved student learning outcomes.

Of those studies that have been done to assess TBL as a course-long strategy and its effect on learning outcomes, researchers have found mixed results (Fatmi, Hartling, Hillier, Campbell, & Oswald, 2013; Haidet et al., 2014; Sisk, 2011). This may be due in part to modifications made to the TBL process, differences between study groups, and faculty comfort with TBL, in addition to other factors. Most studies compared immediate outcomes only, via the assessment of data produced by individual and/or team in-course examinations (Bleske et al., 2014; Fatmi et al., 2013; Maslakpak et al., 2015). Only one author assessed retention of key material following course completion, through data collected 48 hours after class conclusion (Burgess, McGregor, & Mellis, 2014; McColgan et al., 2013; Sisk, 2011; Tan et al., 2011).

This study made a comparison between the learning outcomes of two relatively homogenous groups of students, utilizing the same or, in the case of the National Physical Therapy Examination – Physical Therapist Assistant, comparable assessment tools. One group of students was taught using a lecture-based method, and one group was taught using TBL, exactly as outlined by Michaelsen and Sweet (2008).

Literature review

Active learning has been found to be more successful in producing self-regulation in students than traditional, lecture-focused instruction (Ruckert, McDonald, Birkmeier, Walker, Cotton, Lyons, Straker, & Plack, 2014). Sungur and Tekkaya (2006) found that, when comparing two large groups of students who either received traditional lecture instruction or who engaged in problem-based learning (PBL), PBL students had higher levels of intrinsic goal orientation, task value, use of learning strategies, critical thinking, metacognitive self-regulation, effort regulation, and peer learning. These findings were supported by Sangestani and Khatiban (2013), who found that even the addition of PBL to traditional lecture improved application of theory in clinical practice, increased learning motivation, and enhanced activity in class. PBL as compared to lecture has been found to increase academic achievement; improve students' attitudes towards each other; increase self-esteem, self-direction, and role taking abilities; improve students' sense of responsibility for their own learning and teach students the skills necessary for life-long learning (Griffith, 1990).

Active learning results in fulfillment of the principles outlined by Chickering and Gamson (1987). Active learning provides students with individual and social occasions to actively construct learning through experience while lecture is less likely to involve direct student-faculty contact (Jones, 2010, as cited in Mennenga, 2010).

Active Learning Strategies vs. Passive Learning Strategies for Improved Outcomes in Healthcare Education

Instruction via lecture remains the most common teaching method used in medical education. Lecture is teacher-centered and discipline based, and is an efficient method that allows for the delivery of current, up-to-date information to a class of any size (Altintas et al., 2014). However, due to its passive nature, lecture may not prepare students to critically think about material, or to make clinical decisions. Research demonstrates that the development of critical thinking is inversely proportional to the amount of time that students spend passively listening, and retention of passively delivered material is poor, even when students are provided with a rich summary of the material covered in lecture (Altintas et al., 2014). Consequently, medical and allied health educators are challenged to identify teaching strategies that increase student engagement and result in meaningful learning. Active learning, as compared to lecture, has been proven to increase student learning through interaction and discussion among student peers (Janssen, Kirschner, Erkens, Kirschner, & Paas, 2010).

Active learning can be defined as any instructional method that requires that students partake in meaningful learning activities that require not just participation, but also thinking about participation. In practice, active learning takes place in a classroom environment, and is not inclusive of homework or other types of projects that students do independently outside of the classroom. Active learning has been found to improve student attitudes, thinking, and writing (Prince, 2004). Johnson, Johnson, & Smith (2014) found statistically significant effects for active learning correlated with improved academic achievement, quality of interpersonal interaction, student self-esteem, and perception of social support. Springer, Stanne, and Donovan (1999) supported these findings, and also cited improved retention in academic programs.

According to Lou, Abrami, Spence, Poulsen, Chambers, and d'Applonia (1996) cooperative learning is a strategy that can be employed to encourage active learning. Cooperative learning, as described in Elberson, Vance, Stephenson, and Corbett (2001), is a structured, systematic instructional strategy used in small groups to achieve a common goal.

Eng (2009) outlined the following eight principles of cooperative learning that encourage active learning: 1) students who engage in cooperative learning learn more and are more successful academically; students learn to listen to others' views, to share ideas, and to construct new understanding; 2) students should be organized into heterogeneous groups, which encourage individuals of different backgrounds, genders, ages, and experiences to work together and to generate more ideas from multiple perspectives; 3) members of groups

that have common goals often help one another to learn; 4) cooperative learning encourages individual accountability, which results in group success; 5) equal opportunity for participation must be encouraged through specific techniques that eliminate the potential for one or two group members to dominate, or for a group member to avoid contributing to the group; 6) peer interactions in cooperative groups offer opportunities for students to engage in active knowledge construction; 7) cooperative learning encourages students to not only learn course material, but also to develop team work and collaborative skills, such as taking turns and checking others' understanding; and 8) students who are granted autonomy take responsibility for their own learning, and may practice metacognitive skills that inform as to how and what might be done to improve understanding (Eng, 2009).

Eng's principles result in the common characteristics of cooperative and collaborative learning structures: 1) students organized into small groups focused on a common learning objective; 2) interdependence within the group; 3) group members attempt to help one another; and 4) there is individual and group accountability (Breneiser, Monetti, & Adams, 2012).

Team-Based Learning in Healthcare Education

Team-based learning (TBL) is a method of collaborative learning that is gaining acceptance as an instructional technique appropriate for medical and allied health education. First used in a health professions course at the Baylor College of Medicine in 2001 (Haidet et al., 2014), TBL has found a place at multiple schools of medicine, nursing, pharmacology, dentistry, and to a limited extent, physical therapy. However, studies of the effectiveness of TBL as a means of improving learning outcomes present inconsistent results, often due to the lack of uniformity between approaches, measurement of results, methods of reporting, or the utilization of only parts of the overall TBL method as described by Michaelsen, the method's founder (Fatmi et al., 2013). Fatmi et al. (2013) reported that, when currently available research was assessed for consistency with the specifics of team-based learning as described by Michaelsen et al. (2004), only fourteen of over three hundred studies were identified as consistent.

Team-Based Learning in Physical Therapy Education

Only one study was found that assessed the use of TBL in physical therapy education. Team-based learning was implemented in a gross anatomy course during the first semester of a three-year curriculum. Researchers found that students reported a significantly higher level of satisfaction with the course than did a previous cohort who did not participate in a TBL course (Livingston et al., 2014).

Methodology

This study used a quantitative, quasi-experimental, ex post facto design to examine the effectiveness of team-based learning intervention versus a traditional, instructor-led lecture-

based teaching method on student learning outcomes measured during the course and following graduation from the PTA program.

The following elements of the study made it unique:

1. TBL methodology was used to design the TBL course exactly as described in Larry Michaelsen's (2004) foundational text.
2. The TBL method was utilized for the delivery of the entire content of the course, as opposed to just units of material.
3. The same faculty member taught both courses.
4. The four examinations were identical for students in both courses, and the National Physical Therapy Examination – Physical Therapist Assistant, a standardized measure, assessed retention of material months later.
5. Demographic information was available for all students, permitting an analysis of confounding variables.

Participants

Participants included students who were enrolled in the lecture-based course in 2013 and students who were enrolled in the team-based learning course in 2015. Students from both courses took identical written examinations during their respective courses, and both groups took the National Physical Therapy Examination – Physical Therapist Assistant (NPTE-PTA) following graduation. Although the two cohorts took the NPTE-PTA in different years (the first cohort in 2014, and the second cohort in 2016), these board examinations were psychometrically similar, based on the National Physical Therapy Examination - Physical Therapist Assistant (NPTE-PTA) Test Content Outline, effective January 2013 (Federation of State Boards of Physical Therapy, 2013). No Informed Consent was required for this study, as the data was in existence prior to the study's development.

Instrumentation

Examinations used during the courses were instructor-created and utilized, updated, and modified over a nine-year period. The examinations were specific to neither course design, but assessed understanding and application of key concepts. Content validity of the course examinations was verified through expert assessment and reliability was obtained by administering the same tests to students in the intervening course. Course examination scores for both the lecture and TBL cohorts were previously recorded in Canvas, the college's learning management system. NPTE-PTA examination results and content breakdown and scoring were obtained from the Federation of State Boards of Physical Therapy (FSBPT).

The NPTE-PTA is a standardized, national licensure board examination that is developed, maintained and administered by the Federation of State Boards of Physical Therapy. The FSBPT continually researches and uses the best examination methodology available to ensure validity of the examination. It is written by members of the professional physical therapy

community and undergoes rigorous psychometric analysis; the question bank for the examination is updated every five years.

Data Collection Procedures

Data collection procedures included retrieval of archived student examination scores from Canvas, the college's learning management system. Examination scores were retrieved from fall of 2013 for the lecture-based intervention group, and fall of 2015 for the TBL intervention group. All student identification information was removed. Average scores were collected for the NPTE-PTA Neuromuscular and Neurological System content from 2014, for the lecture-based intervention group who graduated in that year. The average scores were collected for the neuromuscular and neurological system content of the NPTE-PTA Neuromuscular and Neurological System from 2016, for the TBL intervention group who graduated in that year.

Method of Data Analysis

Data analysis was completed utilizing IBM SPSS Statistics® version 25. Analysis of covariance (ANCOVA) was used to compare the effect of lecture course design vs. TBL design on student learning outcomes during the course as measured by in-course examinations, and following graduation, as measured by content scores on the NPTE-PTA. Covariates for analysis were gender, age, race, and GPA prior to the start of the neurorehabilitation course. Demographic characteristics were compared for students in the lecture group and in the TBL group.

Results and Discussions

Prior to all statistical analyses, the dataset was restricted to respondents who were either in the lecture group (n=17) or the TBL group (n=16). Inferential statistics were used for testing the differences between the means of the two groups. An ANCOVA was run to determine the effect of instructional methods on learning outcomes as measured by in-course examination scores and NPTE-PTA Neuromuscular and Neurological System content group averages, after controlling for pre-course GPA. There was a linear relationship between the covariate of pre-course GPA and examination scores for each examination, for each intervention group, as assessed numerically and by visual inspection of a scatterplot. There was homogeneity of regression slopes as the interaction term was not statistically significant. There was homoscedasticity and homogeneity of variances, as assessed by visual inspection of a scatterplot and Levene's test of homogeneity, reported for each dependent variable, below.

Descriptive Statistics: The participants for this study consisted of 33 second-year students in two iterations of the neurorehabilitation course in a physical therapist assistant program. The majority of students were female (78.8%) and Caucasian (87.9%). The percentage of

students in the lecture course (51.5%) was nearly equal to the percentage of students in TBL course (48.5%). The average age for all students was 28 years of age and the average pre-course GPA was 3.48 on a 4.0 scale. The average examination scores for Exam 1 (78.9%), Exam 2 (79.70%), and Exam 3 (78.79%), were slightly below a B. The average examination score for Exam 4 was a B (80.94%). The average NPTE-PTA Neuromuscular and Neurological System content score was 671.20 on an 800-point scaled score. The mean scores for each in-course examination was slightly lower for the lecture group than for the TBL group: for Exam 1 lecture group (77.24) and TBL group (80.81%); for Exam 2 lecture group (78.9%) and TBL group (80.5%); for Exam 3 lecture group (77.18%) and TBL group (80.5%); for Exam 4 lecture group (77.94%) and TBL group (84.12%).

Statistical analysis: A one-way analysis of covariance (ANCOVA) was conducted where the independent variable included a treatment group (TBL) and a control group (Lecture), the dependent variable was Exam 1 scores, and the covariate was pre-course GPA. The ANVOCA was non-significant, $F(1, 29) = 3.187$, $MSE = 329.200$, $p = 0.085$.

The results from the statistical analysis of the participants regarding the TBL within physical therapists are interpreted in tabular form. The ANCOVA are presented in Table 1, 2, 3, & 4 in the results sections. These results from the statistical analysis are interpreted to give meaning to the quantitative data.

Table 1: *Results for exam 1, Analysis of Covariance (ANCOVA) Results for Exam 1*

Independent Variables	df	MSE	F	p	Partial Eta Square
Instruction	1, 29	397.890	3.852	0.059	0.117
GPA	1, 29	652.258	6.314	0.018	0.179
Instruction * GPA	1, 29	329.200	3.187	0.085	0.099

The strength of relationship between the independent variable and the dependent variable was weak as assessed by a partial $\eta 2$, with the independent variable accounting for 9.9% of the variance in the dependent variable, holding constant GPA scores. The results of the ANCOVA suggest that there is no difference in Exam 1 scores between the students taught with lecture and the students taught with TBL when controlling for GPA.

A one-way analysis of covariance (ANCOVA) was then conducted where the independent variable included a treatment group (TBL) and a control group (Lecture), the dependent variable was Exam 2 scores, and the covariate was pre-course GPA. The ANVOCA was significant, $F(1, 29) = 8.456$, $MSE = 499.417$, $p = 0.007$. The results are shown in Table 2.

Table 2: *Analysis of Covariance (ANCOVA) Results for Exam 2*

Independent Variables	df	MSE	F	p	Partial Eta Square
Instruction	1, 29	550.987	9.329	0.005	0.243
GPA	1, 29	643.452	10.894	0.003	0.273
Instruction * GPA	1, 29	499.417	8.456	0.007	0.226

The strength of relationship between the independent variable and the dependent variable was moderate as assessed by a partial η2, with the independent variable accounting for 22.6% of the variance in the dependent variable, holding constant GPA scores. The means for the treatment group and control group were adjusted for initial differences: the treatment group mean was 80.762, while the control group mean was 75.040. The results of the ANCOVA suggest that the TBL group scored higher on average on Exam 2 (M = 80.762) than the lecture group (M = 75.040).

A one-way analysis of covariance (ANCOVA) was conducted where the independent variable included a treatment group (TBL) and a control group (Lecture), the dependent variable was Exam 3 scores, and the covariate was pre-course GPA. The ANVOCA was non-significant, F (1, 29) = 0.003, MSE = 0.103, p = 0.954, as shown in Table 3.

Table 3: *Analysis of Covariance (ANCOVA) Results for Exam 3*

Independent Variables	df	MSE	F	p	Partial Eta Square
Instruction	1, 29	2.066	0.066	0.799	0.002
GPA	1, 29	289.611	9.290	0.005	0.243
Instruction * GPA	1, 29	0.103	0.003	0.954	0.000

The strength of relationship between the independent variable and the dependent variable was non-existent as assessed by a partial η2, with the independent variable accounting for 0.0% of the variance in the dependent variable, holding constant GPA scores.

A final one-way analysis of covariance (ANCOVA) was conducted where the independent variable included a treatment group (TBL) and a control group (Lecture), the dependent variable was Exam 4 scores, and the covariate was pre-course GPA. The ANCOVA was non-significant, F(1, 29) = 2.555, MSE = 102.401, p = 0.121.

Table 4: *Analysis of Covariance (ANCOVA) Results for Exam 4*

Independent Variables	df	MSE	F	p	Partial Eta Square
Instruction	1, 29	165.749	4.136	0.051	0.125
GPA	1, 29	680.342	16.978	0.000	0.369
Instruction * GPA	1, 29	102.401	2.555	0.121	0.081

The strength of relationship between the independent variable and the dependent variable was weak as assessed by a partial η2, with the independent variable accounting for 8.1% of the variance in the dependent variable, holding constant GPA scores. The means for the treatment group and control group were adjusted for initial differences: the treatment group mean was 85.512, while the control group mean was 74.981.

To investigate whether NPTE-PTA Neuromuscular and Neurological System scores varied as a function of TBL versus Lecture, an Independent Samples t-Test was hand calculated. With respect to NPTE-PTA Neuromuscular and Neurological System scores, no statistically significant difference was found in the data ($t = 1.315$; $df = 14$; $p = 0.198$). Thus, the mean of the Lecture group ($M = 686.9$) is not statistically different from the mean of the TBL group ($M = 659.6$).

Discussion

While many previous studies of the use of TBL have been completed, there have been few studies that have followed the guidelines of Michaelsen et al. (2004) in their entirety, or that have focused on learning outcomes as opposed to student satisfaction, faculty satisfaction, or student engagement (Currey, Oldland, Considine, Glanville, & Story, 2015; Ku, Tseng, & Akarasriworn, 2013; Livingston et al., 2014; Roh, Lee, & Mennenga, 2014). While multiple studies have been completed with medical, nursing, pharmacy, and other allied health students, only one previous study focused on students in physical therapy education (Livingston et al., 2014), and only one measured retention of knowledge past the end of the course (Tan et al., 2011).

Due to the homogeneity of the student groups, the study was able to focus on the comparison of the two instructional methods without confounding variables related to the subjects. The examinations used as measurement instruments had been revised and refined over several years, and past students who had taken the in-course examinations had demonstrated success on the neurological concepts' sections of the National Physical Therapy Examination – Physical Therapist Assistant, which supported the content validity of those examinations. The TBL course was designed with the assistance of members of the Team-Based Learning Cooperative, which resulted in verified congruence with TBL principles. Finally, it is a strength of this study that all demographic and academic data was readily available and complete for all of the students included.

Recommendations

This study was completed with a very small group of homogenous students, in one PTA program; therefore, it is recommended that future studies utilizing TBL include a larger, more diverse group of students, and to assign students to the TBL and lecture-based groups by random assignment. Eighty-eight percent of students included in this study were Caucasian, and 79% were female. Consequently, it would be interesting to use a true randomized sample of students who represented different races and ages, and who more equally represented both genders. Also, while teams were developed intentionally, the TBL class had enough students for only three teams. As TBL was originally designed for large classes (Michaelsen, 2004), performing a similar study in a larger class may make the results of TBL more apparent.

It would also be valuable to complete this study as a mixed design that includes qualitative data, such as student feedback. This study focused on learning outcomes, without taking into account student satisfaction, time on task, improved team skills, or other factors, all of which may have been effected by the instructional method. It would be worthwhile to perform this study with assessment of some of the other factors reportedly impacted by TBL, such as the development of self-directed learning behaviors that may translate into increased confidence and motivation in learning, and the enhancement of the learning environment.

Conclusions

The purpose of this research study was to compare the effectiveness of team-based learning versus traditional, lecture-based, teacher-led learning in a neurorehabilitation course within a physical therapist assistant program. This study was completed with second-year physical therapist assistant students enrolled in a neurorehabilitation course in a physical therapist assistant program. Neurorehabilitation is a difficult course that is taught over a ten-week quarter and requires intensive reading, participation in lab, and independent study for the students. This study retrospectively evaluated student learning outcomes during two iterations of the course, as evidenced by in-course examination scores, and learning outcomes in neuroscience overall as evidenced by scores on the National Physical Therapy Examination – Physical Therapist Assistant Neuromuscular and Neurological Systems content, taken by students following graduation. One group of students was enrolled in a lecture-based version of the course; one was enrolled in a TBL-based version. A total of 33 students participated in this study.

Use of TBL modifies how students approach and learn material (Michaelsen et al., 1997). The in-course examinations and the NPTE-PTA are primarily comprised of application questions. Consequently, this study posited that students who engaged in TBL, and who had practiced basic application tasks during the class, would perform better on application-based examinations than those students who engaged in traditional, lecture-based coursework (Mennenga, 2013). The overall results of this study are consistent with other studies in which there were no significant differences in outcomes found between TBL and other instructional methods (Carmichael, 2009; Conway, Johnson, & Ripley, 2010; Koles et al., 2005;

Mennenga, 2010). However, the lack of a significant difference between the two groups does indicate that TBL is at least as effective as traditional, lecture-based instruction (Mennenga, 2010; Weiner, Plass, & Marzfhadidet, 2009). Therefore, teachers in physical therapist assistant programs might consider adding TBL to their curricula in the interest of capitalizing on its benefits outside of improved learning outcomes (Haidet, Schneider, and Onady 2008).

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