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Team-based Learning Compared to Lecture-based Learning among Pharmacology Students

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Team-based Learning Compared to Lecture-based Learning among Pharmacology Students

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by

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Contents

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Executive Summary

Healthcare educators play a vital role in the learning process by providing high quality, effective teaching strategies for future healthcare workers. Unfortunately, lecture-based learning (LBL) remains a dominant method of instruction despite yielding poor knowledge acquisition and retention, poor academic performance, inadequate professional skill acquisition, and decreased student interest and attention. As a current educator in the Allied Health Science department at Austin Community College (ACC), LBL remains the dominant teaching methodology in pharmacology courses. Team-based learning (TBL) is an alternative teaching strategy to LBL that improves academic performance, improves exam scores, provides students with necessary skills to succeed in their professions, and lightens the load on nursing faculty (Cheng et al, 2014a; Cheng et al., 2014b; Fatmi et al., 2013). TBL's benefits sparked a personal spirit of inquiry due to the department's main teaching pedagogy of LBL, the college's current high student attrition rates, low graduation rates, diverse student learning styles, limited student resources, faculty resistance to changing teaching strategies, and a lack of professional skills gained by students that are necessary for the workplace. With ACC's current graduation rates at 7.2%, providing students with effective teaching strategies is of utmost importance given the parallel to academic performance (Garza, 2019). The current proposition is to implement TBL as the dominant teaching methodology in pharmacology courses at Austin Community College to improve the students' academic performance, improve exam scores, and increase the chances for academic success.

Team-based Learning Compared to Lecture-based Learning among Pharmacology Students

Healthcare educators play a pivotal role in the learning process as they work to provide academic excellence through high quality, effective teaching methodologies. Unfortunately, lecture-based learning (LBL) remains a dominant teaching pedagogy in colleges and universities around the world despite its link to poor student academic performance (Jaschik, 2018). With LBL, students miss 40% of what is being presented. Students in LBL classrooms retain only 70% of what is being taught during the first 10 minutes of lecture and only 10% in the last 10 minutes, and they lose attention and interest in the content as lecture continues (Janssen et al., 2008). Undergraduate students in LBL courses are 1.5 times more likely to fail than students in active learning classrooms (Bajak, 2014). Fortunately, team-based learning (TBL) is an alternative teaching methodology that improves academic performance, provides students with necessary professional skills for their intended careers, increases the student's ability to succeed academically, and decreases the workload on nursing faculty (Cheng et al., 2014a; Cheng et al., 2014b; Fatmi et al., 2013). Using TBL as an alternative to LBL improves student engagement, communication, team building, and knowledge retention, and it enforces active learning (Ofstad & Brunner, 2013). TBL cultivates an environment for students to acquire professional skills and abilities, such as interpersonal skills, collaborative skills, giving and receiving feedback, knowledge acquisition, and real-world application, that are necessary for their intended careers. TBL increases the appreciation for the value of teams and self-directed learning (Cheng et al., 2014b; Parmelee, 2008). Compared to LBL, TBL students have higher exam scores, higher percentages of A letter grades, and improved academic performance (Morris, 2016). According to Morris (2016), second year undergraduate nursing students achieved a 100% passing rate when TBL was used as the instructional methodology. TBL is currently used globally in schools

of medicine, nursing, dentistry, pharmacy, residency programs, and health-related continuing education and has shown improvements in knowledge scores in health education courses (Fatmi et al., 2013). With TBL, students come to class prepared and are fully engaged. One faculty member can handle an entire session of TBL making it suitable for large classes given high student enrollments with less nursing and pre-nursing faculty available (Morris, 2016; Parmelee, 2008). Poor academic performance leads to attrition and lower graduation rates which contribute to the nursing shortage. However, TBL yields greater potential for academic success (Cheng et al., 2014a). This paper aims to discuss an evidence-based practice (EBP) change in the current teaching methods from LBL to TBL in pharmacology courses at Austin Community College (ACC).

Rationale for the Project

LBL remains the dominant teaching pedagogy in pharmacology courses at ACC despite yielding poor academic performance and lower test scores (Jaschik, 2018). This internal evidence shows a need for change. Students desire a teaching strategy that fosters an environment for academic success. Students have diverse learning needs and frequently express a desire for groupwork and study groups. With the vast increase in technology use, communication and interpersonal skills are subpar among students. New graduates need to be equipped with a variety of professional skills that LBL does not foster, such as critical thinking and application of knowledge (Fatmi et al., 2013). Many U.S. health-related educators feel that LBL cannot produce competencies required of health professionals despite its continued use (Cheng et al., 2014a). Upon personal reflection of current teaching environments at ACC, the pharmacology faculty are resistant to changes in instructional methodologies outside of LBL due to limited understanding of more effective learning models and teaching strategies such as TBL.

With poor graduation rates and faculty continuing to utilize lecture as the dominant teaching modality in pharmacology courses, it is crucial for ACC pharmacology faculty to implement TBL as the alternative given its parallel to academic success, improved exam scores, and equipping students with a multitude of skills that will be utilized in their intended careers (Fatmi et al., 2013; Garza, 2019).

Literature Synthesis

The basis of the suggested recommendation for TBL stems from a detailed review of the literature. As shown in Appendix A, 12 articles, ranging from level I to level IV, provide substantial evidence in support of improved exam scores with TBL over LBL. The review of the literature provides sound evidence that TBL is the best practice for improving academic success. Upon synthesis across the studies, all 12 keeper studies show good levels of evidence including three level I, four level II, three level III, and two level IV studies. All keeper studies use good statistical tests for the levels of measurement, have a control and an intervention of LBL and TBL respectively, and show improved academic performance with TBL. All keeper studies include courses with health-related course material and measure academic performance using test scores. All keeper studies have good quality of evidence; ten studies provide a high level of certainty that the intervention provides substantial benefit for students while two studies provide a moderate level of evidence. All keeper articles from the literature review contain well-designed studies with good rigor, and all utilize student populations working toward health-related degrees. Nine of the twelve studies reference and align with strong TBL frameworks. Overall, synthesis across the keeper studies show good strength, high quality, strong rigor, and high level of evidence in support of TBL over LBL. Furthermore, all 12 keeper studies show increased exam scores when TBL is utilized over LBL (Bleske et al., 2016; Branson et al., 2016; Chen et

al., 2018; Echeto et al., 2015; El-Banna et al., 2019; Kim et al., 2016; Lang et al., 2019; Lein, Jr. et al., 2017; Travis et al., 2016; Whittaker, 2015; Yan et al., in press; Zeng et al., 2017).

Project Stakeholders

The current population involved in this EBP change project include community college students in pre-nursing pharmacology classes at ACC. The stakeholders include the faculty, the students, the department chair, the dean, the leadership of the college, ACC as a whole, future healthcare employers, and the community receiving care. All stakeholders desire for academic success for the student population as they are the future of healthcare delivery. Students desire for the best academic setting that fosters an environment for academic success. Leadership promotes ideologies and methodologies that cultivate a positive atmosphere for students to attain the goal of graduation and employment in their intended careers. In addition, there is also the issue of reputation. Leadership desires for a positive reputation regarding student success and academic excellence in their prospective programs because that is what attracts students to apply for acceptance into the college and its programs.

The literature points out that TBL fosters an environment for academic success because it consistently results in improved academic test scores when compared to the dominant teaching methodology of LBL that ACC pharmacology faculty utilize (Kim et al., 2016). Students also have greater learning enthusiasm with TBL (Lang et al., 2019). Of extreme importance is that students report having a higher preference for TBL as a teaching methodology over LBL (Branson, et al., 2016). Students also overwhelmingly report a positive attitude toward TBL when it is utilized in the classroom (Bleske et al., 2016; Chen et al., 2018; Zeng et al., 2017). Students desire for this preference based on the improved academic outcomes that result when TBL is used over LBL.

While leadership holds to a high standard of academic excellence, faculty may have resistance to the change due to increased faculty workload on creating TBL activities, concern about faculty evaluations, feeling comfortable with the status quo, and a lack of knowledge on the TBL teaching methodology. Workshops, collaboration, and proper training will be utilized to alleviate faculty concerns and possible resistance.

Change is inevitable with education and healthcare. Resistance is extremely common. Establishing a solid plan for this change project will reduce resistance by communicating the logic of change to faculty and administrators, providing the evidence in the literature, increasing faculty participation and collaboration in the change efforts, developing positive relationships among colleagues, and building a system of support and commitment for change efforts (Darnell et al., 2017).

Implementation Plan

The overall goal of this change project was to determine the effectiveness of TBL over LBL on exam grades in pharmacology pre-nursing students in the community college setting. The site of anticipated change was in the ACC classroom of approximately 30 students. There was diversity with age and ethnicity, most students had similar education levels, and most were Caucasian females. Few students had prior health-related knowledge. Classrooms contained substantial space, tables, chairs, whiteboards, and technology for feasible implementation of TBL. Given the current COVID-19 guidelines, students were participating in face-to-face courses this spring 2021 semester utilizing Zoom for the technology platform. Breakout rooms, Blackboard Collaborate, FaceTime, and conference calls allowed for feasibility of TBL activities while remaining socially distanced.

The overall plan of the project was to utilize TBL in a pharmacology section of 30 pre-nursing students, the intervention group, and to utilize LBL in a pharmacology section of 30 pre-nursing students, the control group. The data on the average of the three unit exam grades were then obtained for each section from Blackboard, and compared, to determine how TBL affected exam grades. The timeframe for this project was 8 weeks.

Initially, a clear vision was developed for the TBL change project. Population preferences were obtained regarding teaching methodologies of TBL and LBL. The subsequent step included determining if any protocols were in place at ACC that could create obstacles and barriers to completing the change project. The next step, and one of the most critical in this process, was presenting evidence from the literature regarding the benefits of improved academic performance, improved exam scores, and improved academic success when TBL is used over LBL. Using evidence from the literature as the foundation to implement change promotes excellence and results in improved outcomes (Rodgers et al., 2019). The literature, after analysis and appraisal, provided high level of evidence and high quality studies that were conducted with good rigor. The evidence showed the effectiveness of TBL over LBL for improved academic performance and test scores. Presenting the results with clarity and conciseness was key for buy-in from stakeholders. Additional data presented to the department chair and faculty included the feasibility of the intervention, the lack of risk, and the value added by implementing this TBL change. Further assessing for additional obstacles and barriers was key. Faculty resistance, technology barriers, and student accommodations were possible concerns. Once these issues were addressed and resolved, creating an environment with enthusiasm, ambition, motivation, and excitement about EBP was vital.

The next step was presenting the data on why a change was needed. LBL remains a dominant teaching methodology in pharmacology courses at ACC despite its link to poor academic outcomes, poor student performance, and increased failing rates about students (Bajak, 2014). In contrast, TBL students consistently perform at a higher academic level with higher exam scores and higher percentages of grades 90 and above (Morris et al., 2016). The additional evidence from the evaluation table in Appendix A was further presented showing the significant impact TBL has on academic performance and improved exam scores compared to LBL (Bleske et al., 2016; Branson et al., 2016; Chen et al., 2018; Echeto et al., 2015; El-Banna et al., 2019; Kim et al., 2016; Lang et al., 2019; Lein, Jr. et al., 2017; Travis et al., 2016; Whittaker, 2015; Yan et al., in press; Zeng et al., 2017). The evidence from the literature was presented through departmental emails and meetings.

Stakeholders impacted include students and their families, faculty, healthcare programs, colleges and universities obtaining ACC students as transfers, healthcare institutions as future employers, the community, and ACC as a whole. To gain support from stakeholders, a detailed presentation was conducted with all faculty and the department chair in health sciences. Students were educated on the benefits of TBL, its uses, and their responsibilities with the activities using evidence obtained from the literature. To encourage collaborative efforts, tap into talents and resources at the college, and create the TBL activities, interdisciplinary teamwork took place utilizing pharmacology faculty, student services, student accessibility services, education department faculty, instructional design specialists, and learning lab specialists. TBL activities were then created and developed to transform education practices.

For weeks 2-8, the EBP change project was piloted utilizing the control group, LBL, and the intervention group, TBL. Students were provided with guidance and training on successful

completion and participation in TBL activities. The faculty member conducting the change project continued to function as a facilitator for the activities. Throughout weeks 2-8, feedback was obtained from students regarding preference, feasibility, and barriers on completing the TBL activities with group members. This feedback was utilized to continue refining the processes of the TBL intervention as needed. Data were collected and analyzed beginning week 2 and processes continued to be refined to ensure there was no risk to students with the intervention and to ensure students had the appropriate resources to complete the TBL activities. During week 3 and ongoing, this was a time for observation, waiting, and allowing time to see a change occur.

At week 8, the project was completed. Data continued to be analyzed. During this time, outcomes of the mean unit exam scores in each of the two sections were measured. The evidence will be disseminated to the department chair and pharmacology faculty from the EBP change project on TBL's effectiveness on mean unit exam grades. The dissemination will occur through email and as a PowerPoint presentation at the summer 2021 departmental meeting. Since the results warrant a change to be implemented departmentally, it is anticipated that the TBL change will be implemented department-wide. Education and training will be provided to all faculty and staff. The successful completion of this project is and will continue to be celebrated.

Timetable

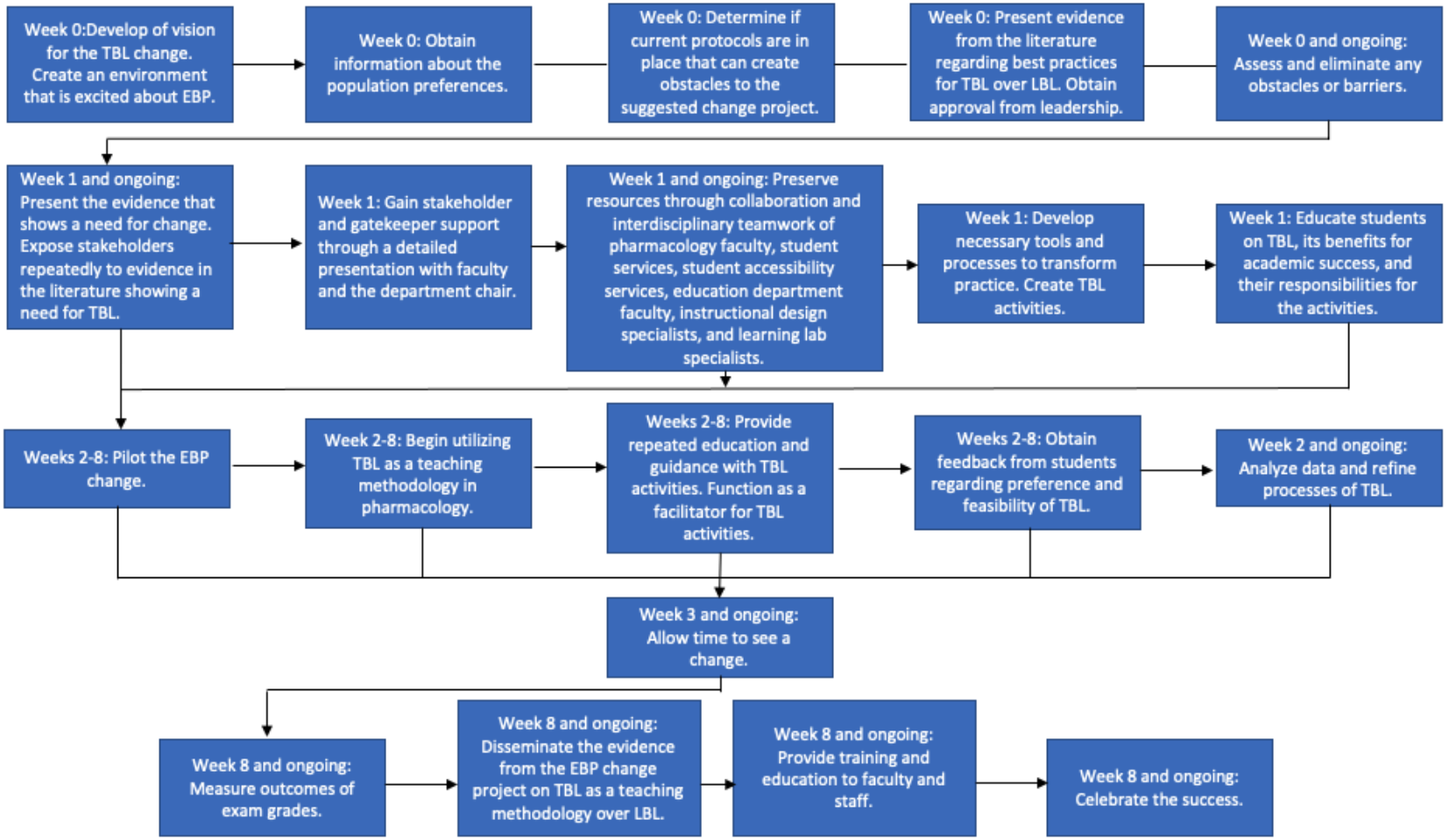
For successful implementation, a timeline is essential.

- Week 0: Develop a vision for the TBL change. Create an environment that is excited about EBP.
- Week 0: Obtain information about the population preferences.
- Week 0: Determine if current protocols are in place that can create obstacles to the suggested change project.
- Week 0: Present evidence from the literature regarding best practices for TBL over LBL. Obtain approval from leadership.
- Week 0 and ongoing: Assess and eliminate any obstacles or barriers.
- Week 1 and ongoing: Present the evidence that shows a need for change. Expose stakeholders repeatedly to evidence in the literature showing a need for TBL.

- Week 1: Gain stakeholder and gatekeeper support through a detailed presentation with faculty and the department chair.
- Week 1 and ongoing: Preserve resources through collaboration and interdisciplinary teamwork of pharmacology faculty, student services, student accessibility services, education department faculty, instructional design specialists, and learning lab specialists.
- Week 1: Develop necessary tools and processes to transform practice. Create TBL activities.
- Week 1: Educate students on TBL, its benefits for academic success, and their responsibilities for the activities.
- Weeks 2-8: Pilot the EBP change.
- Week 2-8: Begin utilizing TBL as a teaching methodology in pharmacology.
- Weeks 2-8: Provide repeated education and guidance with TBL activities. Function as a facilitator for TBL activities.
- Weeks 2-8: Obtain feedback from students regarding preference and feasibility of TBL.
- Week 2 and ongoing: Collect and analyze data and refine processes of TBL.
- Week 3 and ongoing: Allow time to see a change.
- Week 8 and ongoing: Measure outcomes of exam grades.
- Week 8 and ongoing: Disseminate the evidence from the EBP change project on TBL as a teaching methodology over LBL.
- Week 8 and ongoing: Provide training and education to faculty and staff.
- Week 8 and ongoing: Celebrate the success.

(Rodgers et al., 2019).

Flowchart



The flowchart is also found in Appendix B.

Data Collection Methods

Data collection occurred using Blackboard, the Learning Management System that ACC utilizes. Exam grades are calculated through Blackboard, so manual retrieval of exam scores from the grade center was conducted by the faculty teaching the two sections of pharmacology. Exam scores were input into a Microsoft Excel spreadsheet using manual data entry for ease of analysis and calculation. As each unit exam was completed and calculated, exam score data were collected. Mean exam scores for unit 1, unit 2, and unit 3 were calculated for the LBL group and for the TBL group. Means for each unit exam for each group were compared to determine TBL's effectiveness as the project progressed. Graphs were created to compare the data utilizing Microsoft Excel.

The evaluation step of the evidence-based practice initiative determines how the intervention affects the outcomes or how effective the intervention was in a particular population or setting (Melnyk & Fineout-Overholt, 2019). A significant change or effectiveness was defined as a 5% increase in each unit exam mean when TBL was utilized. This increase will provide substantial benefit for students with improved chances of academic success for the course. This benefit will also counter the added costs than may incur due to implementation of this teaching modality department-wide.

The potential outcomes included: TBL improves unit exam grades, and TBL does not improve unit exam grades. The expected outcome was: TBL improves unit exam grades in pharmacology pre-nursing students with a 5% increase in mean unit exam scores. This outcome was determined to be significant with a recommended practice change. This outcome was expected due to the high level of evidence found in the literature that supports TBL over LBL at improving exam scores (Bleske et al., 2016; Branson et al., 2016; Chen et al., 2018; Echeto et al.,

2015; El-Banna et al., 2019; Kim et al., 2016; Lang et al., 2019; Lein, Jr. et al., 2017; Travis et al., 2016; Whittaker, 2015; Yan et al., in press; Zeng et al., 2017).

Success occurs when data collection, analysis, and outcome evaluation yield results showing TBL improves mean unit exam scores by 5%. This will provide necessary data for dissemination of new evidence to all faculty and the department chair in the Allied Health Science (ALHS) department at ACC. This will increase the likelihood of a department-wide change in educator practices that can lead to improved student performance and improved academic success. Monitoring for best practices regarding teaching methodologies will continue following a practice change of TBL.

Cost/Benefit Discussion

Funding and increased costs are always associated with change projects. Important questions to consider are: Is funding available to cover the costs of the practice change implementation, and do the benefits counter the costs to implement the recommended practice change? Expected costs include training faculty and staff on TBL practices and developing TBL activities for the course. Training can take place through semester departmental meetings. Given the current pilot of the implementation, half of the activities have already been completed. Additional time can be utilized by providing a stipend to faculty involved in the activity creation process. ACC currently provides a vast array of resources for teaching, so no additional costs should be incurred for implementation. With a 5% increase in mean unit exam scores, this can determine whether a student passes or fails the course. This increase can also contribute to improving the passing rate for the college, improving the reputation of the college at providing academic excellence, and improving the associated professional skills, such as problem-solving ability, communication skills, thinking ability, self-study ability, critical thinking, and leadership

and management skills, that students gain when TBL is utilized as a teaching strategy as evidenced in the literature (Bleske et al., 2016; Branson et al., 2016; Echeto et al., 2015; Kim et al., 2016; Lang et al., 2019; Lein, Jr. et al., 2017; Travis et al., 2016; Whittaker, 2015). Minimal costs will be incurred from implementation, and the benefits far outweigh the costs.

Discussion of the Results

The results of this piloted EBP implementation provide solid evidence that TBL increases the means of each of the three unit exam scores in the pharmacology TBL course when compared to the LBL course. The LBL group had mean unit exam scores of 87.24%, 71.29%, and 75.66% for units 1, 2, and 3 respectively as shown in Appendix C. The TBL group had mean unit exam scores of 92.34%, 79.51%, and 81.36% for units 1, 2, and 3 respectively as show in Appendix D. Across the data, the TBL group experienced a percentage increase of 5.1, 8.22, and 5.7 on mean exam scores for units 1, 2, and 3 respectively as shown in Appendix E. This significant increase provides evidence of substantial benefit of improved academic success and improved exam scores. In addition, over 79% of students in the TBL group reported a preference for TBL over LBL. These results provide evidence that TBL is a superior teaching methodology compared to LBL to increase the average of unit exam scores, to foster an environment for improved academic performance, and to cultivate a greater potential for student academic success. The compiled results provide evidence that the current, more dominant practice of LBL that is currently being utilized in the ALHS department at ACC is not the best teaching practice and leads to poorer student academic outcomes. Furthermore, the results show this piloted practice change for TBL is significant, successful, and necessary.

Conclusion/Recommendations

This project seeks to implement best practices for teaching in pharmacology courses at ACC. Considering educator expertise, student preferences, the evidence in the literature, and the results of this pilot study, it is recommended that a practice change occur that implements TBL over LBL for all pharmacology courses at ACC. The results provide evidence that students prefer TBL over LBL, and students perform better academically on exam scores and have a greater chance of academic success with TBL. It is recommended that all faculty, leadership, and colleagues support this recommended change in a collaborative effort to provide best practices for the ACC pharmacology student population.

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Appendix A

Evaluation table

PICOT Question: In pharmacology pre-nursing students at a community college (P), how do team-based learning (TBL) activities (I) compared to no team-based learning activities (C) affect the average of three unit exam grades (O) in an 8 week period (T)?
PICOT Question Type (Circle): Intervention Etiology Diagnosis or Diagnostic Test Prognosis/Prediction Meaning

Caveats

1) The **only studies** you should put in these tables are the ones that **you know answer your question** after you have done rapid critical appraisal (i.e., the keeper studies)
2) Include APA reference
3) Use abbreviations & create **a legend** for readers & yourself
4) Keep your descriptions brief – there should be **NO complete sentences**
5) This evaluation is for the purpose of knowing your studies to synthesize.

Place your APA References here (Use correct APA reference format including the hanging indentation):

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Citation: (i.e., author(s), date of publication, & title)	**Conceptual Framework**	**Design/ Method**	**Sample/ Setting**	**Major Variables Studied and Their Definitions**	**Measurement of Major Variables**	**Data Analysis**	**Study Findings**	**Strength of the Evidence (i.e., level of evidence + quality [study strengths and weaknesses])**
Author, Year, Title	**Theoretical basis for study Qualitative Tradition**		**Number, Characteristics of the sample (not Inclusion/exclusion criteria), Attrition rate & why?**	**Independent variables (e.g., IV1 = IV2 =)** **Dependent variables (e.g., DV =)**	**What scales were used to measure the outcome variables (e.g., name of scale, author, reliability info [e.g., Cronbach alphas])**	**What methods were used to answer the clinical question (i.e., all stats do not need to be put into the table)**	**Statistical findings (i.e., for every statistical test you have in the data analysis column, you should have a finding) or qualitative findings (themes and subthemes)**	• **Strengths and limitations of the study (Consider the validity of the study and/or flaws In the method not just what Is stated as limitations)** • **Risk of harm if study intervention or findings implemented** • **Feasibility of use in your practice** • **Remember: level of evidence (See Melnyk & Finout-Overholt handout) + quality of evidence = strength of evidence & confidence to act** • **Use the USPSTF grading schema http://www.ahrq.gov/clinic/3rduspstf/ratings.htm**
ARTICLE #1 Kim, H.-R., Song, Y., Lindquist, R., & Kang, H.-Y. (2016). Effects of team-based learning on problem-solving, knowledge and clinical performance of Korean nursing students.	None stated but authors reference studies using Michaelsen's TBL strategy and Mennega's and Smyer's model	Quantitative Experimental RCT	N=63 IG=32 CG=31 Convenience sampling with random assignment to IG/CG Avg age about 22 Heavier male pop than female 3rd yr nrsg st from CUCNSK Korean st-college classroom setting	DV=PSA, K, CP IV=TBL TBL-st-centered learning, structured sequence of activities, active learning PSA-higher level Bloom's i.e. analyzing, applying, creating, evaluating	Lee's PSA scale-Cronbach's alpha=0.85 K questionnaire-2 professors verified validity CP checklist->0.80 content validity index	Mean SD % Fisher's test x^2 *t* test	NSS in BC of SocD and PSA scores b/w CG and IG **IG/TBL scored higher** on PSA, K, and CP (t=10.89, p<0.001; t=10.21, p<0.001; t=12.22, p<0.001) **All SS** TBL inc PSA, K, and CP more than CG PSA dec in CG	**<u>For each of the following, bullet or number items</u>**: 1.Strengths: • Good rigor • Convenience sampling with random group assignment • Good reliability scores with instruments • Evaluators are exp nurses • Clinical checklist completed with live person vs questionnaire • Consistency throughout process in CG and IG • Same content in CG and IG • Similar pop • Similar course content • No attrition • Good statistical tests 2. Limitations: • Small sample • Short timeframe-3wks • Poss breach of confidentiality • Topic limited to pulmonary • Pop limited to 3rd yr nrsg

			Most have GPA 3.0 or above Most are satisfied with major No attrition					• Pop lacks diversity, Korean students only 3. Risk of harm: • None 4. Feasibility: • Easy to implement • Support of leadership • Willing student participation • Extra preparation time and faculty concern with st evaluations 5. Level of evidence for the PICOT question type: • Level II 6. Quality of the evidence: • Good **USPSTF: Grade: A** **Level of Certainty: High**
ARTICLE #2 Lang, B., Zhang, L., Lin, Y., Han, L., Zhang, C., & Liu, Y. (2019). Team-based learning pedagogy enhances the quality of Chinese pharmacy education: A systematic review and meta-analysis.	None given	Review MA	12 articles involving 1271 participants Published 2013-1018 Systematic literature search-PRISMA Searched 6 databases using TBL, team-based learning, pharmac*, pharmac* education, pharmac* students Chinese pharmacy st	DV=TS (primary); LE, SSA, TA, CS (secondary) IV=TBL	Course grading=TS Questionnaires=not specified for LE, SSA, TA, CS	SMD 95% CI RR Heterogeneity (x^2, Tau^2, I^2, df) Egger's test Begg's test Sensitivity analysis	(SMD=2.55, 95% CI [1.56, 3.55], p<0.00001)=**TBL inc TS; SS** Begg's, p=0.373 Egger's, p=0.049; publication bias, results reliable after SA (95.49%-TBL; 64.87%-LBL; RR=1.38, 95% CI [1.13, 1.69], p<0.0001, I^2=83%)=**TBL inc LE; SS** (93.4%-TBL; 70.97%-LBL; RR=1.32, 95% CI [1.21, 1.43], p<0.0001, I^2=32%)=**TBL inc SSA; SS** (93.69%-TBL; 58.79%-LBL, RR=1.45, 95% CI [1.04, 2.02], p<0.0001, I^2=88%); removed study for heterogeneity →(92.68%-TBL; 74.39%-LBL; RR=1.24, 95% CI [1.08, 1.43],	1.Strengths: • Good rigor • RCTs only • Good sample size • Same intervention of TBL used in all studies • All studies measured TS • Similar pop • Similar course content • Good statistical tests 2. Limitations: • Heterogeneity present • Chinese population only • Pharmacy curricula only • Chinese institutions only • Only 4 questionnaires to measure secondary outcomes and those differed 3. Risk of harm: • None 4. Feasibility: • Easy to implement • Support of leadership

			TBL as intervention LBL as comparison RCTs only All measured TS 4 had questionnaires (4-LE/SSA, 3-TA, 2-CS)			Subgroup analysis	*p*<0.0001)=**TBL inc TA; SS** (93.18%-TBL; 76.15%-LBL; RR=1.22, 95% CI [1.10, 1.36], *p*<0.0001, I^2=0%)=**TBL inc CS; SS** **SS for all,** *p*<0.0001 for 3 yr vs 4yr st and TO vs EO courses	• Willing st participation • Extra preparation and faculty concern with st evaluations 5. Level of evidence for the PICOT question type: • Level I 6. Quality of the evidence: • Good **USPSTF: Grade: A** **Level of Certainty: High**
ARTICLE #3 Yan, C., Li, B., Liang, H., & Ma, X. (in press). Impact of team-based learning on radiology education: A systematic review and meta-analysis.	None given	Review MA	12 articles involving 1371 participants RCTs Systematic literature search of 6 databases using keywords and heading titles to include TBL OR team-based learning AND medical imaging OR radiology OR MRI OR CT OR Echo OR ultrasound TBL as IG LBL as CG Medical imaging courses Medical st and trainee doctors in medical	IV=TBL DV=TTS and STS	Course grading schemes using MCQ, gap fillings, essay questions-TTS Graded on film reading, medical record writing, case dx-STS No authors or additional info given on scoring	95% CI Standardized mean difference (SMD) Subgroup analysis Sensitivity analysis Heterogeneity: I^2 test x^2 df Tau^2 *Q* statistic	-**TBL improves TTS compared to LBL** (SMD=1.07, 95% CI [0.50, 1.63], *p*=0.0002, I^2=95%); **SS** (error on p. 7) -subgroup analysis, lower grades=(SMD=1.74, 95% CI [0.47, 3.02], *p*=0.007, I^2=98%); **SS** -subgroup analysis, higher grades= (SMD=0.63, 95%CI [0.28, 0.97], *p*=0.0004, I^2=76%); **SS** -**TBL improves STS compared to LBL** (SMD=0.68, 95% CI [0.19, 1.17], *p*=0.006, I^2=93%); **SS** -subgroup analysis, lower grades= (SMD=0.85, 95% CI [0.05, 1.64] *p*=0.04, I^2=94%); **SS** -subgroup analysis, higher grades= (SMD=0.56, 95% CI [-0.21, 1.33] *p*=0.15, I^2=93%); **Not SS**	1.Strengths: • Good rigor • RCTs used only • Good sample size • Same intervention of TBL used in all studies • All studies measured TS • Similar pop in lower grade to PICOT pop • Similar course content • No attrition • Good statistical tests 2. Limitations: • Signficant heterogeneity present • Medical imaging curricula only • Grammatical concers and in text errors on p. 6-7 of article • Under peer review • Division of groups, higher grade with trainee doctors, much above the PICOT pop in education • No clear standard of scoring on exams • Level of radiology education varies in Chinese medical schools • Pop lacks diversity 3. Risk of harm: • None 4. Feasibility: • Easy to implement • Support of leadership • Willing st participation

			colleges and teaching hospitals Outcomes measured: TTS and STS published in Chinese published 2014-2019 from 3 databases 679-TBL group (typo on pg. 6 of article) 692- LBL group 5 studies included freshmen and sophomores (lower grade) 7 studies included older st and trainee doctors (higher grade) sample sizes range from 15-177 3 studies are theory 9 studies are theory and practice No attrition			Egger's test Begg's test	**Significant heterogeneity** TTS; t=0.33, p=0.748 STS; t=1.01, p=0.344 **No pub bias** **No substantial asymmetries for TST or STS**	• Extra preparation and faculty concern with st evaluations 5. Level of evidence for the PICOT question type: • Level I 6. Quality of the evidence: • Good **USPSTF: Grade: A** **Level of Certainty: High**

ARTICLE #4 Branson, S., Boss, L., & Fowler, D. L. (2016). Team-based learning: Application in undergraduate baccalaureate nursing education.	Dr. Michaelsen's TBL approach and Mennega and Smyer's model for implementation into nursing courses	Quantitative Quas-experimental (post-test)	221 undergraduate senior nursing st Convenience IG=102 CG=119 78% female 43% white Diverse ethnicities Mean age 28 yrs All in baccalaureate program 3 credit hr professional practice course Enrolled in sections and CG were courses in spring 2014 IG were courses in summer 2015 Recruited from state-funded school in metropolitan city in southern U.S. No attrition for required HESI® exam	DV=AP, CT, LMS, OCR, ATLTBL, PTBL/PLBL, LSTBL IV=TBL	HESI® standardized exam-AP online survey for end of semester course evaluations (no measure given) Cronbach's α = 0.88 for TBL-SAI	Descriptive statistics: Mean, SD, % two-tailed independent *t*-tests	54% LBL 46% TBL Female 78% White 43% Mean age 28 yr TBL had higher HESI scores/AP, t=12.64; p<0.01; **SS** TBL learners - higher degrees of CT (t=2.76; p<0.01), higher degrees of LMS (t=4.33; p<0.01), better OCR (t=6.45; p<0.01) compared to LBL learners; **all SS** TBL – moderate to high level ATLTBL, M=33.33 (3.73); higher PTBL, M=56.67 (11.06); high LSTBL, M=36.02 (8.05); totals moderate to high for favorable experiences with TBL M=126.02 (12.77); good reliability	1.Strengths: • Good rigor • Quasi-experiment with CG • Good sample size per power analysis and Cohen's *d* • Good reliability and validity • Same faculty, same content in courses • Faculty were trained on TBL, piloted course, refined, and launched • Student anonymity on surveys and no effect on grades • No attrition for AP on test scores • Used strong framework 2. Limitations: • No randomization • All st did not complete surveys • Post-test only • No x^2 to measure BC in Soc-D • Completed during different semesters, usually summer is shorter in length 3. Risk of harm: • None 4. Feasibility: • Easy to implement • Support of leadership • Willing student participation • Extra preparation and faculty concern with st evaluations 5. Level of evidence for the PICOT question type: • Level III 6. Quality of the evidence: • Good **USPSTF: Grade: A** **Level of Certainty: High**

			-61 st completed end-of-semester course evaluations, -43 st completed TBL-SAI survey					
ARTICLE #5 Zeng, R., Xiang, L.-r., Zeng, J., & Zuo, C. (2017). Applying team-based learning of diagnostics for undergraduate students: Assessing teaching effectiveness by a randomized controlled trial study.	Guidelines of TBL interventions by Haidet, Levine, and Parmelee	Quantitative RCT small amt of qualitative data from teacher interviews)	111 3rd year Chinese medical st Chinese medical school Avg age 20 About 50/50 ratio for males to females Avg grades in main courses prior to this class 79-80 Random assignment to IG and CG using computer random digital method Convenience sampling No attrition	DV=TS, SATBL, LTTBL IV=TBL Phenomena=TATBL	Tests-teacher-prepared St survey-used domestic and foreign literature, combined with teaching practice	Descriptive statistics: mean, SD, %, ratio x^2 *t* tests Wilcoxon test 95% CI ANOVA (*F* value) Stratification analysis Subgroup analysis	Mean age 20 28:27 IG male to female 29:27 CG male to female Avg grades for main courses 79-80% No SS of baseline b/w IG and CG TBL ITT1 and CG ITT1 (19.85±4.20, 19.70±4.61, [-1.501, 1.817], *t*=0.189, *p*=0.851); **No SS** TBL ITT2 and CG ITT2 (19.15±3.93, 17.46±4.65, [0.061, 3.301], *t*=2.057, *p*=0.042); **SS** TBL comparing ITT1 to IRAT and ITT2 to IRAT, *p*<0.001; **SS** LTTBL before and after class (91.09±45.11, 90.45±37.1), LTLBL (26.61±11.91, 41.16±18.36), *t*=10.256, 8.847; *p*<0.001; **SS** TBL subgroups IRAT to ITT1 and IRAT to ITT2, *p*>0.05; **NSS** Pairwise comparison of all academic levels had significant differences in IRAT, ITT1, ITT2, *p*<0.05; **SS**	1.Strengths: • Good rigor • Randomization • Minimized confounding variables-same text, syllabus, practice instruction b/w IG and CG • Consistent teachers, testing schedules, and exams b/w IG and CG • No attrition • Used strong framework 2. Limitations: • Restricted content • Short time frame of intervention • Lack of diversity in pop 3. Risk of harm: • None 4. Feasibility: • Easy to implement • Support of leadership • Willing student participation • Extra preparation and faculty concern with st evaluations 5. Level of evidence for the PICOT question type: • Level II 6. Quality of the evidence: • Good **USPSTF: Grade: A** **Level of Certainty: High**

						Thematic analysis	SATBL mostly positive (60-80%) IRAT, ITT1, ITT2 at all academic levels had significant differences, p<0.001; **SS** TBL-higher TS at one week, higher improvement with IRAT/ITT1 and IRAT/ITT2, longer learning times TATBL mostly positive	
ARTICLE #6 Chen et al. (2018). Meta-analysis on the effectiveness of team-based learning on medical education in China.	Michaelsen's TBL model	Review MA	13 articles involving 1545 participants 2-RCTs 11-non-RCTs Literature search of inception through December 2015, 4 Chinese and 3 English databases searched. Keywords used: Team-based learning, TBL, theory, theoretical, China, Chinese, medicine, medical, disease,	IV-TBL DV-TTS, SATBL, & LSKTBL.	Theoretical exams for TTS but no info provided on author. Questionnaire used for SATBL/LSKTBL but no author or reliability scale provided.	SMD 95% CI I^2 Begg's test Sensitivity and subgroup analyses Coefficient/ meta-regression	**TBL increased student TTS compared to LBL** (SMD=2.46, 95% CI: 153-3.40, I^2 =98.0%, p<0.001)[i] **SS** **TBL has positive effects on SATBL→** (SMD=3.23, 95% CI: 2.27-4.20, I^2=92.1%, p<0.001); **SS;** **and LSKTBL→** (SMD=2.70, 95% CI: 1.33-4.07, I^2=97.4%, p<0.001); **SS** **No asymmetry; no pub bias** (p=0.059) **Significant heterogeneity TTS positively related to education levels and randomization** (p=0.041, 0.021) **Female only medical college st reached homogeneity** (I^2=9.4%, p=0.332)	1.Strengths: • Good rigor but used non-RCTs • Mostly good sample sizes • Same intervention of TBL used in all studies • Same control of LBL used in all studies • All studies measured TTS • Similar pop to PICOT pop • Similar course content • No attrition • Good statistical tests • Searched Chinese and English databases • Used 3 investigators and Newcastle-Ottawa scale for quality 2. Limitations: • Only 2 RCTs • Significant heterogeneity present • Lack of diversity in pop • No clear standard of scoring on exams • No info on authors of exams or reliability scales for questionnaires • Questionnaires only used on 4 & 5 studies for SATBL/LSKTBL • 4 studies are female only 3. Risk of harm:

			health, healthy, biology, biological, hygiene, hygienic, pharmacology, pharmacological. TBL as IG LBL as CG No attrition. Outcomes measured: TTS, SATBL, & LSKTBL (by all studies). 4 studies measured SATBL. 5 studies measure LSKTBL. Medical discipline courses. 7 studies-undergraduate college students, 6 studies-medical college students. 9 studies include male/female. 4 studies are female only.					• None 4. Feasibility: • Easy to implement • Support of leadership • Willing st participation • Extra preparation and faculty concern with st evaluations 5. Level of evidence for the PICOT question type: • Level I (but used non-RCTs as well) 6. Quality of the evidence: • Good **USPSTF: Grade: A** **Level of Certainty: High**

			Published in Chinese Most studied students from 2008-2013. Sample sizes-64-270. TBL-772 participants, LBL-773 participants.					
ARTICLE #7 El-Banna, M. M., Whitlow, M., & McNelis, A. M. (2019). Improving pharmacology standardized test and final examination scores through team-based learning.	Michaelsen's TBL model	Cohort	N=330 CG=110 IG=228 Students from ABSN program over 3-year period 5 cohorts with 3 cohorts using a pre- and post- test design Cohorts 1, 2 use LBL Assume same criteria for program admission and equivalent programs of study Convenience sampling	IV-TBL DV-TS (FTS, StanTS)	Final exam-no reliability scale or author given; constructed by 2 faculty, detailed blueprint, item analysis. Stardardized exam-good reliability reported, no Cronbach's alpha reported	Mean Standard deviation Independent *t* tests X^2 Pearson correlation coefficient (*r*) Percentages	**FTS SS with TBL over LBL** **TBL FTS** (97.11, 4.37) **LBL StanTS** (88.61, 5.11) (*t*=-15.83, *p*<0.001) **StanST SS with TBL over LBL** **TBL StanTS** (62.17, 9.40) **LBL Stan TS** (59.79, 8.39) (*t*=-2.25, *p*<0.05) SS for level of attainment (yes/no) and approach (1, N=338) = 43.19, *p*<0.001) Proficiency likelihood 45.2%-TBL 19.1%-LBL Positive correlations b/w final exam and standard exam (*r*=0.240, *p*<0.001)	1.Strengths: • Good rigor for cohort • Good sample size • Same intervention of TBL • Same control of LBL • Measured TS • Similar pop to PICOT pop • Similar course content • No attrition noted • Good statistical tests • Used 2 experienced instructors for exam creation • Company for standard exam reports good reliability 2. Limitations: • Cohort, lower level evidence • Assumption of program admission criteria and program of study • Minimal demographics of population • No clear standard of scoring on exams • No reliability scales 3. Risk of harm: • None 4. Feasibility: • Easy to implement • Support of leadership • Willing st participation • Extra preparation and faculty concern with st evaluations 5. Level of evidence for the PICOT question type:

								• Level IV 6. Quality of the evidence: • Good **USPSTF: Grade: B** **Level of Certainty: moderate**
ARTICLE #8 Bleske, B. E., Remington, T. L., Wells, T. D., Klein, K. C., Guthrie, S. K., Tingen, J. M., Marshall, V. D., & Dorsch, M. P. (2016). A randomized crossover comparison of team-based learning and lecture format on learning outcomes.	None.	Quantitative RCT Crossover design	30 28-2nd yr students, 2 prior TBL courses 2-3rd year students, 4 prior TBL courses Therapeutics course Random assignment IG-TBL CG-LBL Winter term Convenience sampling	IV=TBL DV=RQS, AQS, RAQS, SATBL, CPT	Exam 1 and 2-faculty created and evaluation Questionnaire (Qualtrics, Provo, UT) measuring preference-Likert scale Yes/no approach for confidence-questionnaire-no author	Mean Standard deviation Independent *t* tests Cohen's *d* Percentages	**RAQS with TBL SS** TBL RAQS [89.2% (10.6)] LBL RAQS [85% (10.2)] *p*=0.03 5/6 (83.3%) of Likert scale questions **SA TBL favor TBL SS** *p<0.01*- p=0.05 [3.87 (0.9); 2.57 (0.86); 2.6 (1.07); 3.83 (0.79); 3.70 (0.99)] Yes/no approach – Students have **SATBL favor TBL, greater confidence with TBL SS with 2/4 questions** [4.10 (0.84)TBL,3.53 (0.94)-LBL, *p*=0.03, 0.64; 4.43 (0.57)-TBL, 3.00 (1.07)-LBL, *p*<0.01, 1.69]	1.Strengths: • Good rigor for randomized crossover • Good level of evidence • Same intervention of TBL • Same control of LBL • Measured academic performance using TS • Similar pop to PICOT pop • Similar course content-medical-related • No attrition noted • Good statistical tests • Used 3 experienced instructors for exam creation • Students showed increased performance on all types of questions with TBL but SS was with RAQS • No decrease in performance using TBL with all question types 2. Limitations: • Small sample size • Only 48 questions were used to assess • One exam question was essay-based, subjective grading • No x^2 to provide demographics data and heterogeneity • Minimal demographics of population given • No clear standard of scoring on exams • No reliability scales on survey • Used 6 faculty for teaching • possibility for instructor bias • Only SS with RAQS 3. Risk of harm: • None 4. Feasibility: • Easy to implement • Support of leadership

								• Willing st participation • Extra preparation and faculty concern with st evaluations 5. Level of evidence for the PICOT question type: • Level II 6. Quality of the evidence: • Good **USPSTF: Grade: A** **Level of Certainty: high**
ARTICLE #9 Travis, L. L., Hudson, N. W., Hendricks-Lepp, G. M., Street, W. S., & Weidenbenner, J. (2016). Team-based learning improves course outcomes in introductory psychology.	Michaelsen's TBL model	Quantitative RCT	1126 Undergraduate students Fall semester All pharmacology course students Random group assignment to IG or CG Convenience sampling	IV=TBL DV=MTS, FTS SATBL	Midterm exam-analyzed by 2 judges on TBL content alignment Final exam-no author noted Course satisfaction survey-Likert scale Student perception of TBL survey	Mean Standard deviation Independent *t* tests Cohen's *d* Percentages 95% CI OR	**MTS with TBL higher SS** OR=1.18 (1.04, 1.34) **Greater probability for TBL of answering correctly on midterm** TBL 73.1% (71.4, 74.7) probably of currently answering questions on midterm, LBL 69.7% (67.8, 71.6) **With MTS, TBL higher on application exercises** OR=1.48 (1.29, 1.70) **Greater probably for TBL of answering correctly on midterm application questions** TBL 80.5% (79.0-82.0) LBL 73.7% (71.7, 75.5) FTS – no SS with TBL over LBL **With FTS, TBL SS higher on application exercises with higher probably to answer application questions correctly** TBL OR 1.16 (1.09, 1.25), 80.8% (78.5, 82.9) LBL OR=1.29 (1.05, 1.59), 76.5% (73.7, 79.1)	1.Strengths: • Good rigor for RCT • Good level of evidence • Same intervention of TBL • Same control of LBL • Measured academic performance using TS • Similar pop to PICOT pop-medical-related undergraduate students • Similar course content-medical-related-psychology • Attrition is addressed • Good statistical tests • Used same midterm, same final, same course satisfaction survey • Instructors received TBL training • TBL students had higher odds of answering test questions correctly that covered TBL content 2. Limitations: • 10/15 were teaching the course for the first time • Only 48 questions were used to assess • One exam question was essay-based, subjective grading • No x^2 to provide demographics data and heterogeneity • Minimal demographics of population given • No clear standard of scoring on exams • No reliability scales on survey • No author given for final exam • No control on time spent per topic • Inexperienced instructors (grad st)

							No SS with questions covering non-TBL content No differences in SATBL and LBL	3. Risk of harm: • None 4. Feasibility: • Easy to implement • Support of leadership • Willing st participation • Extra preparation and faculty concern with st evaluations 5. Level of evidence for the PICOT question type: • Level II 6. Quality of the evidence: • Good **USPSTF: Grade: A** **Level of Certainty: high**
ARTICLE #10 Echeto, L. F., Sposetti, V., Childs, G., Aguilar, M. L., Behar-Horestein, L. S. Rueda, L., & Nimmo, A. (2015). Evaluation of team-based learning and traditional instruction in teaching removable partial denture (RPD) concepts.	Michaelsen's TBL model (not mentioned in the article, but referenced on the reference list)	Quantitative Quasi-experimental	166 Senior level dentist students Patient care for 5 semesters RPD course concepts Convenience sampling	IV=TBL DV=TS	Exam-instructor authored, multiple simultaneous evaluators	Mean Standard deviation Independent *t* tests X^2 Odds ratio Percentages	**LBL** students 48.1% passing rate with 72 or higher, grade range 87-47 Mean grade for LBL 0.700 (SD=0.092) **OR passing under LBL 2.746, 2X more likely to fail if LBL** **TBL students have higher passing rate SS-** 71.8% passing rate with 72 or higher, grade range 92-51; 23.7% improvement **SS** p=0.002 Mean grade for TBL 0.758 (SD=0.083) **TBL higher class average SS p<0.001 with effect size at 0.62**	1.Strengths: • Good rigor for quasi-experiment • Good level of evidence-III • Same intervention of TBL • Same control of LBL • Measured academic performance using TS • Similar pop to PICOT pop-senior level dentist students • Similar course content-medical-related-dentistry • Good statistical tests • Sam exam used with both groups • TBL students have higher passing rates and higher class averages • LBL students are 2.5X more likely to fail than TBL students 2. Limitations: • No x^2 to provide demographics data and heterogeneity • Minimal demographics of population given • No clear standard of scoring on exams-subjective area • Attrition not addressed 3. Risk of harm:

								• None 4. Feasibility: • Easy to implement • Support of leadership • Willing st participation • Extra preparation and faculty concern with st evaluations 5. Level of evidence for the PICOT question type: • Level III 6. Quality of the evidence: • Good **USPSTF: Grade: A** **Level of Certainty: high**
ARTICLE #11 Whittaker, A. A. (2015). Effects of team-based learning on self-regulated online learning.	Michaelsen's TBL model Bandura's self-regulated learning model	Quantitative Quasi-experimental	184 IG-86 CG-98 Junior level nursing st Course-nursing research/EBP Convenience sampling	IV=TBL DV=TS, CPT	2 MC exams-Kuder-Richardson 0.52, 0.75, with biserial correlations < 0.20	Mean Standard deviation Independent *t* tests X^2 Percentages	**TBL st SS greater CPT than IL st** (*t*=-6.126, df=182, *p*<0.001) IL group-13%, no CPT 12%-viewed 90-100% of material TBL group-50% viewed 90-100% of material Had 62% fewer st with no CPT **TBL st SS higher mean exam scores** (*t*=-2.961, df=182, *p*=0.003) IL mean 0.756 (0.076) TBL mean 0.788 (0.071) TBL mean was 3.43 points higher than IL mean 17.35% of IL st scored below 70% 9% of TBL st scored below 70% No SS between IG and CG	1.Strengths: • Good rigor for quasi-experiment • Good level of evidence-III • Same intervention of TBL • Same control of IL/LBL • Measured academic performance using TS • Similar pop to PICOT pop-junior level nursing st • Similar course content-medical-related-nursing • Good statistical tests • TBL students have a higher mean on TS than IL students • TBL students have greater CPT than IL st • No SS difference b/w IG and CG • Instructor has TBL experience 2. Limitations: • Different exams for IG and CG • Researcher taught both IG and CG • Different numbers for IG and CG • Homogeneity of sample (Caucasian women, 20-21) 3. Risk of harm: • None

								4. Feasibility: • Easy to implement • Support of leadership • Willing st participation • Extra preparation and faculty concern with st evaluations • Increased faculty workload to prepare TBL activities 5. Level of evidence for the PICOT question type: • Level III 6. Quality of the evidence: • Good **USPSTF: Grade: A** **Level of Certainty: high**
ARTICLE #12 Lein, Jr., D. H., Lowman, J. D., Eidson, C. A., & Yuen, H. K. (2017). Evaluation of team-based based learning in a doctor of physical therapy curriculum in the United States.	Michaelsen's TBL model	Cohort	552 IG-375 CG-177 Doctor of physical therapy st 1st and 5th semester st Majority female Caucasians, 23-24yrs old University of Alabama Birmingham program-9 senesters No SS with GPA between groups Convenience sampling	IV=TBL DV=BSC TS, CPC TS	3 exams (midterm, final, practical exam)-no author data, assumed to be instructor-created	Mean Standard deviation Independent *t* tests ANOVA Cohen's *d* 95% CI Percentages	BSC: [$F(2, 147)=11.147$, $p<0.0010$]; SS across cohorts w/ TBL, Scheffe test, only 2014 cohort, only 3 pts difference, all used as one group CPC: [$F(3, 139)=0.986$, $p=0.083$]; no SS, one group **BSC mean TS higher with TBL; SS** [$t=3.629$, $p<0.001$; Cohen's $d=0.69$; CI (0.31, 1.07)]; 88.9 ± 3.7 **CPC mean TS higher with TBL; SS** [$t=4.255$, $p<0.001$; Cohen's $d=0.46$; CI (0.24-0.67)], 87.0±5.2 **BSC TS with TBL – 25% increase in A letter grades** **CPC TS with TBL – 15% increase in A letter**	1.Strengths: • Good rigor for cohort study • Moderate level of evidence • Same intervention of TBL • Same control of LBL • Measured academic performance using TS • Similar pop to PICOT pop-medical professional st • Similar course content-medical-related-doctor of physical therapy curriculum • Good statistical tests • TBL students have a higher mean on BSC TS and CPC TS • TBL students in BS and CPC have increase in letter A grades with TBL approach 2. Limitations: • Different numbers for IG and CG-375, 177 • Homogeneity of sample (Caucasian women, 23-24) • Different classes were taught • No randomization 3. Risk of harm:

							grades, 10% decrease in Bs, 5% decrease in Cs	• None 4. Feasibility: • Easy to implement • Support of leadership • Willing st participation • Extra preparation and faculty concern with st evaluations • Increased faculty workload to prepare TBL activities 5. Level of evidence for the PICOT question type: • Level IV 6. Quality of the evidence: • Good **USPSTF: Grade: B** **Level of Certainty: moderate**

Legend:

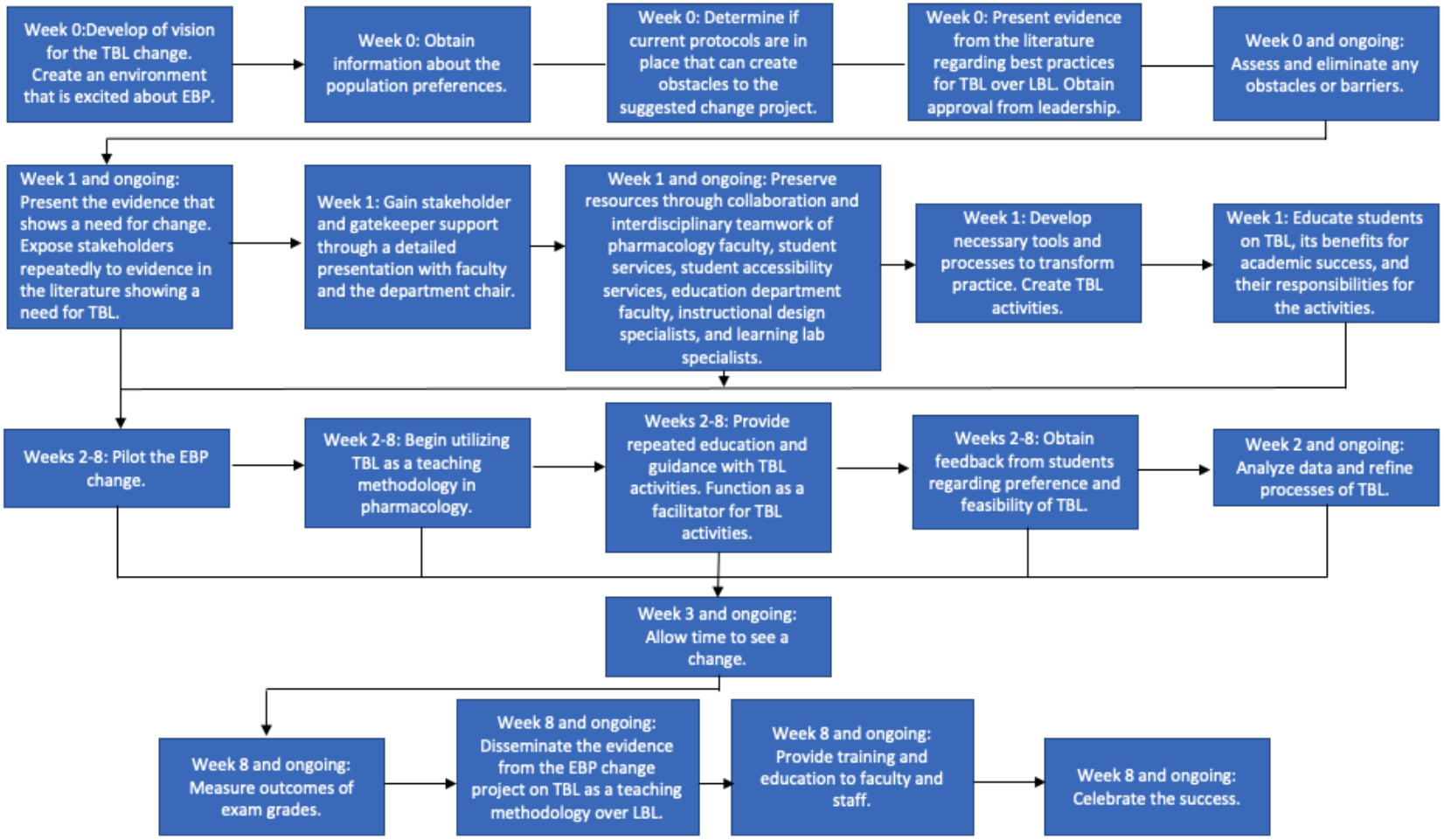
ANOVA-analysis of variance
AP-academic performance
AQS-application question scores
ATLTBL-accountability to learning in TBL
avg-average
b/w-between
BC-baseline comparison
BSC-basic skills course
CG-control group
CI-confidence interval
CoLT-collaborative based learning technique
CP-clinical performance
CPC-cardiopulmonary course
CPT-class prep time
CS-communication skills
CT-critical thinking

CUCNSK-C University College of Nursing in South Korea
dec-decrease
DV-dependent variable
dx-diagnosis
EO-experimental-oriented
exp-experienced
FTS-final test score
GPA-grade point average
IG-intervention group
inc-increase
IV-independent variable
K-knowledge
LBL-lecture-based learning/traditional learning
LE-learning enthusiasm
LMS-leadership and management skills
LSTBL-learner satisfaction with TBL
LSKTBL-learner skills for TBL
LTTBL-learning times for TBL
MA-meta-analysis
MCQ-multiple choice questions
nrsg-nursing
MTS-midterm test scores
NSS-not statistically significant
OCR-overall course ratings
PLBL-preference to learning LBL
pop-population
poss-possible
PSA-problem-solving ability
PTBL-preference to learning TBL
RAQS-recall-application combo question scores
RCT-randomized controlled trial

RPD-removable partial dentures
RQS-recall question scores
RR-risk ratio
SA-sensitivity analysis
SATBL-student attitudes toward TBL
SD-standard deviation
SMD-standardized mean difference
SocD-socio-demographics
SS-statistically significant
SSA-self-study ability
st-student(s)
STS-skills test scores
StanTS-standardized test scores
TATBL-teacher attitudes toward TBL
TA-thinking ability
TBL-team-based learning
TO-theoretical-oriented
TS-test scores
TTS-theoretical test scores

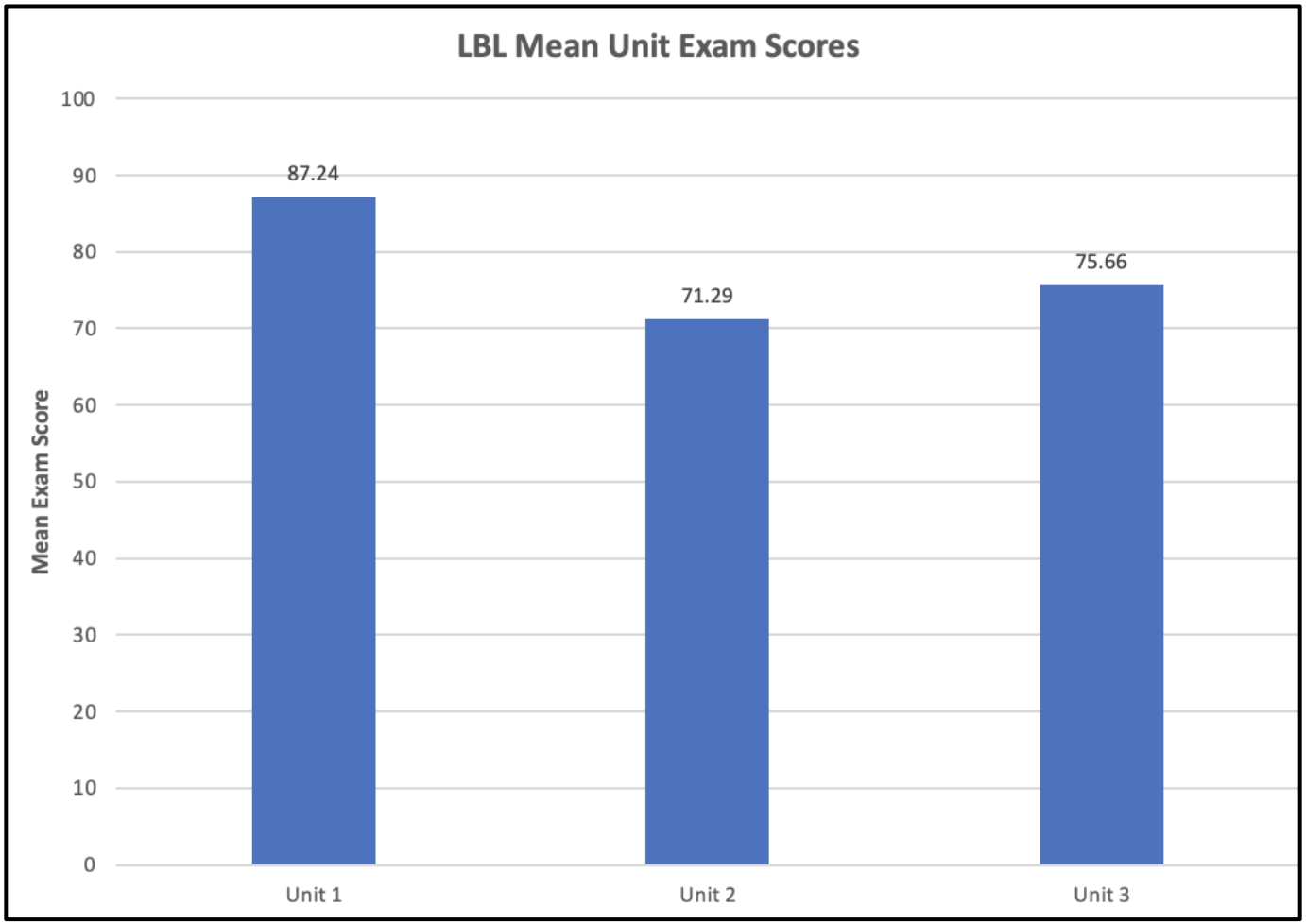
Appendix B

Flowchart



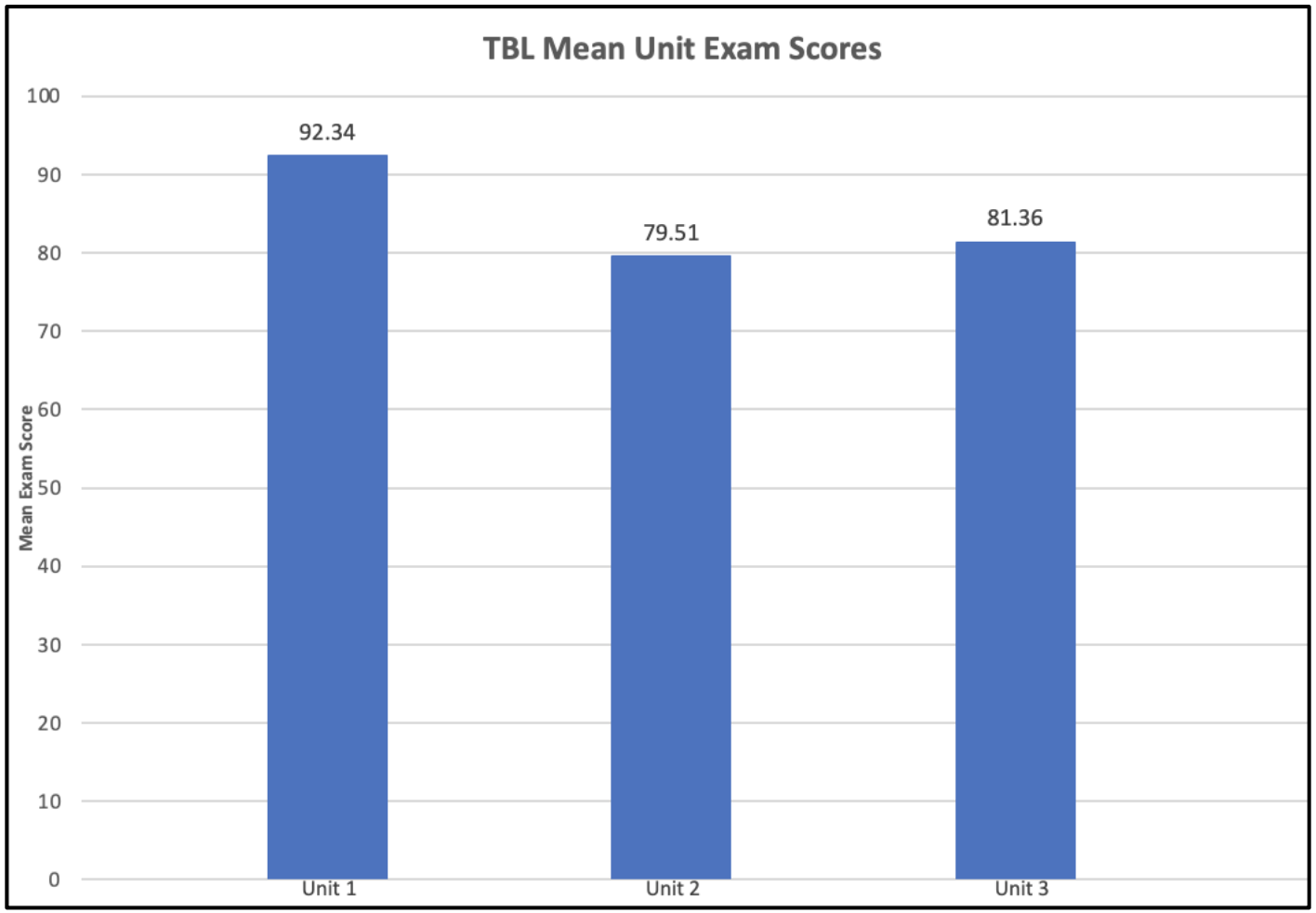
Appendix C

LBL Mean Unit Exam Scores



Appendix D

TBL Mean Unit Exam Scores



Appendix E

TBL and LBL Mean Unit Exam Score Comparison