An Examination of Problem-Based Learning and its Impact on Medical Students' Attitudes and Academic Outcomes: A Meta-Analysis

by

Alexandria L. Brice

A dissertation submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Doctor of Philosophy

Auburn, Alabama
May 7, 2017

Keywords: meta-analysis, active learning, medical students, problem-based learning, attitudinal behavior

Approved by

James E. Witte, Chair, Professor, Educational Foundations, Leadership, and Technology
Maria M. Witte, Professor, Educational Foundations, Leadership, and Technology
Leslie A. Cordie, Assistant Professor of Educational Foundations, Leadership, and Technology
Melody L. Russell, Associate Professor of Curriculum and Teaching

Abstract

This study examined the relationship of Problem-based Learning (PBL) and medical students’ attitudinal behavior and academic outcomes. The analyses of 14 independent, primary studies conducted between 2003 –2016, on 4,981 medical students across various medical schools were included in the study. The data were examined using a meta-analysis technique.

Limits were set as a means to include and exclude research studies. Studies were considered for inclusion if the study resulted in effect sizes or statistics that could be converted to effect sizes. Articles related to academic outcomes and attitudinal behaviors of medical students’ use of PBL were included. Studies that were qualitative in nature were excluded due to the statistical analysis required for meta-analysis. Educational environments outside of medical education environments and education programs outside of medical education were also excluded. Studies were identified and examined to distinguish their congruence within the inclusion criteria.

Studies that were included evaluated: PBL as an active learning technique, PBL in medical classrooms and settings, medical students’ attitudinal behaviors, perceptions, and academic outcomes. Studies that yielded relevant information were retained. This study indicates that medical students’ use of Problem-based Learning had no statistically significant impact on medical students’ attitudinal behavior and academic outcomes.

Acknowledgements

I extend my sincerest thanks to Dr. James Witte and Dr. Maria Witte, for helping me navigate my way thru this process, and for simply being great! To Dr. Melody Russell, and Dr. Jared Russell thank you for your continued kindness, encouragement and support! Dr. Cordie your time and guidance is sincerely appreciated! Thank you all for being an outstanding committee.

To My husband Tim, my real life Boaz thanks for your love, encouragement and support always! To my beautiful reflections of me Tasheila, Mykeita and Emmaree Maxine, I am so very proud of the women that each of you have become. Jaylan and Malcolm I love you both and thanks for loving me back. Ben and Bryon thanks for your absolute greatness! To my favorite little boy and girl in the world Bryce Alexander and Mackenzie Grace – Grandma is back! To my parents Willie and Maxine, thank you for my beginning, your endless support throughout and your unwavering prayers that got me to the end. To my #1 fan my grandmother Mary Emma, thanks for packing great lunches and tagging along with me to campus to babysit the girls while I attended classes; I especially thank you for instilling in me the importance of a good education! Rosie, Hareon and Tara, your support during the early years mean more than you know, thank you! To the best sideline cheerleaders in the world Yogi and Shirl, thank you for always rooting for me! To my sister Donnie, thanks for taking over my grandma duties during this process and thanks for the humor and laughter you add to my life! Vanessa thanks for the inspirational messages that came just when I needed them most! To my nieces and nephews know that greatness is upon you please walk in it! To family and friends who supported me from afar, I thank you!

Lastly, to Mr. Clima White, my mentor, my friend, my role model, you will never be absent in spirit. For every life that I enrich I do it in remembrance of you, in honor of the way you so greatly enriched my life with your laughter, advice and wisdom. I find peace in knowing that I made you proud.

To God be the Glory for without Him and His infinite plan for my life the culmination of this journey would not be possible.

"And we know that all things work together for good to them that love God, to them who are the called according to his purpose."

-Romans 8:28

Table of Contents

List of Tables

List of Figures

List of Abbreviations

COMLEX	Comprehensive Osteopathic Medical Licensing Examination
LS	Learning Style
PBL	Problem-based Learning
STEM	Science, Technology, Engineering, Mathematics

Chapter I: Introduction

The fundamental purpose of medical education is to assist students in the development of skills required to teach themselves (Cooke, Irby, & O'Brien, 2010). Yet, the model pedagogy in the medical classroom is the traditional didactic lecture, in which students are disengaged, invisible, unaccountable and emotionally disconnected most of the time, which do not give support to the development of skills needed to teach themselves (Cook-Sather, 2011). To confront this (Bonwell & Eison, 1991; Brookfield, 2006; Cavanaugh, 2011) suggest that lectures should be intermittent with a variance of learning activities that are well designed to keep students attentive and engaged, which conversely will support their learning.

The Flexner Report

The blueprint for medical education in North America was put into words in 1910 by Abraham Flexner. Henry Pritchett, president of the Carnegie Foundation selected not a physician, scientist, nor a medical educator but instead a novice in the field to conduct the survey (Duffy, 2011). Flexner's exhaustive report, Medical Education in the United States and Canada, a comprehensive survey of medical education was prepared at the request of The Carnegie Foundation for the Advancement of Teaching and at the request of the American Medical Association's Council on Medical Education. One hundred years later structural features prescribed by Flexner remain in position today. For example (scientific foundations) biomedical courses account for the first two years of medical school and clinical (hands-on) experience make up the last two years (Cooke et al. 2010).

The report was rigid and striking in its examination and critique and recommendations for medical schools. Within a short span of time multifold medical schools had closed, as a result of the blueprint. Flexner reports that, “in the thirty years after the publication of his report, the number of American Medical Schools had been reduced from 155 to about 60” (Duffy, 2011 p. 113). Flexner stated that “medical schools are schools and must be judged as such” meaning they must be evaluated by the same standards as education. He also posed the question “are they (medical schools) equipped and conducted as to be able to train students to be efficient physicians, surgeons, and so on?” (Duffy, 2011 p. 108-109). In conclusion, medical education was noted to fall short in many crucial accounts. Flexner concluded the following in his blueprint for medical education: medical training is obstinate, unreasonably lengthy and not student-centered, poor associations between formal knowledge and experiential learning exist, and insufficient interest to patient delivery and effectiveness. Duffy, (2011) quoted:

> “medical education in the U.S. is at a crossroads: those who teach medical students and residents must choose whether to continue in the direction established more than a hundred years ago or take a fundamentally different course, guided by contemporary innovation and new understanding about how people learn. Can medical education’s illustrious past serve as an adequate guide to a future of excellence?” (p.109).

Through visits and evaluations of over one hundred medical schools, Flexner resolved that the pattern for judging all medical schools would be Johns Hopkins for its faculty, instructional practices, academic rigor and signature pedagogies (Shulman, 2005).

Johns Hopkins

Nearing the culmination of the 19th century, discord surrounded U.S medical education. Medical institutions were being compared to trade schools, since many medical students were educated in trade school settings. Admission into trade school was more cumbersome than admission into medical school. The opening of Johns Hopkins Hospital in 1889 changed the face of a medical education. Johns Hopkins was a pioneer in the restructuring of medical education, and serves as a leader in the field today in part due to their practice of medicine, medical research and much improved medical school curriculum (John Hopkins University).

Signature Pedagogies

Lee Shulman's research has centered on teaching and the continuous education of teachers in regards to the understanding of pedagogical content knowledge (PCK), the evaluation of teaching, medical education, the instruction of science, math and medicine, the understanding of educational research and the excellence of teaching in higher education settings. Shulman (2005) defines signature pedagogies as institutional practices that unify the theoretical ways in which future professionals are instructed for their new professions. When signature pedagogies are employed it is more difficult for students to fade away and become unidentified. According to Shulman (2005) instructors have equipped students for professional practices for generations however, their inspection of the instructional practices and penal traditions regarding the educational process is a fairly new experience.

Shulman (2005) suggests that a signature pedagogy is three dimensional and if examined the relevance of each is obvious. Shulman explains, a surface structure consists of concrete, practical acts of teaching and learning, whereas; deep structures replicate a set of assumptions about how to convey understanding and lastly, an implicit structure encompass a mass that involve a set of beliefs about specialized opinions, values and outlooks (Shulman, 2005). Ultimately, signature pedagogies move the emphasis of course content to the higher levels of Bloom's (1956) classification of learning behaviors, and build on a variety of hypotheses about what leads to consequential learning, as depicted in research (Huber & Morreale, 2002; Pace & Middendorf, 2004).

Active learning. Active Learning has been intermittently suggested as a teaching strategy that trumps the traditional didactic lecture (Cook-Sather, 2011). Active learning is an umbrella term used to represent a variation of teaching techniques and occupies a mass area of research in education. Although active learning has recently become a popular term in higher education, the methodology is not new (Miller & Metz, 2014). Active learning is an instructional method in which students become engaged participants in the classroom (Bonwell & Eison, 1991; Chickering & Gamston, 1987; Warren, 1997). Students are responsible for their own learning through the use of interactive lectures, engaging lectures, in-class discussions, written exercises, games, audio response systems, and cooperative learning experiences, i.e. Problem-based Learning. Effective pedagogical practices support intellectual engagement and allow more in-depth learning to occur (Bonwell & Eison, 1991). Research studies have shown definitively through student comprehension, retention, and achievement that student outcomes are enhanced when active instructional strategies replace the traditional didactic lecture (Bonwell & Eison, 1991; Lenz, McCallister, Luks, Le & Fessler, 2015; Machemer & Crawford, 2007; Miller, McNear, & Metz, 2013; Miller & Metz, 2014; Smith & Cardaciotto, 2011; Warren, 1997). Therefore, altered methods of instructional techniques should be used to reach all students in the most effective manner (Komarraju & Karau, 2008).

Numerous research articles have been published on the qualities of active learning, (Bonwell & Eison 1991; Chickering & Gamson, 1987; Cook-Sather, 2011; Davis, 2013; Gregory, 2013; Miller et al. 2013; Miller & Metz 2014; Warren, 1997; Yilmaz, 2014) and cooperatively they report imperative data, to support that these methods without a doubt enhance learning. In a study conducted by Machemer and Crawford (2007) that measured how students value traditional, active, and PBL activities reported that students valued being both passive and active. Machemer and Crawford's (2007) investigation of the relationship between traditional learning (traditional didactic lecture) and active teaching strategies (cooperative learning) yielded inconclusive results. In 2003 and 2005 there were no significant differences. However, in 2004 the traditional mean (4.45) was significantly higher than the active mean (4.24), while in 2002 the opposite occurred, with an active mean of 3.93 significantly higher than the traditional mean 3.68. Given the congruence in results both "aggregated and "disaggregated" (by year) data, additional findings were reported using the aggregated data.

The study was replicated four times over four semesters, where each time class size averaged between 125-180 students. Cooperative and traditional and techniques were rated on an ordinal scale and the values were statistically compared using a mean difference.

Maryellen Weimer (2015) illustrates exquisitely what research supports regarding what we know about learning in any form (Bonwell & Eison, 1991; Warren, 1997) and that is "Learning is harder from the sidelines and if deep understanding is the objective, then the learner had best get out there and play the game" (Weimer, 2015, p. 11). Therefore, watching others problem-solve, think critically, or start an IV may provide a surface level understanding of how it is done, but that is not how you learn to execute on the field.

The umbrella term associated with active learning embodies a variety of pedagogical practices, with each aiding the objective of cultivating an active classroom environment. Active learning strategies are instructional strategies which fully engage students in the learning process through the use of engaging, interactive lectures, class discussions, audience-response systems, educational games, cooperative activities and problem sets.

Active learning pedagogical practices range in the level of complexity, however the effectiveness of each technique depends largely on the instructor's attitude which must shift from thoughts of instructor-centered to student-centered. In fact active learning has been referred to as more of an attitude rather than a method. Any teaching technique that an instructor uses has the potential to be effective, if the technique is student-centered and is used competently, appropriately, and with the right intentions (Hackathorn, Soloman, Blankmeyer, Tennial, Garcynski, 2011).

Multiple studies (Bonwell & Eison, 1991; Chickering & Gamson, 1987; Yilmaz, 2014) indicate that student learning and understanding of course concepts are enhanced when active learning strategies are employed. According to Russell, Comello & Wright (2007) active learning strategies bolter students' engagement which assists them in swaying away from being given facts and figures to developing concepts, understanding principles and applying knowledge in various settings. Findings also indicate that active learning methods leave students with more than surface level knowledge. When students are active participants in the learning process it places them at the center of their learning as they are required to do meaningful learning activities (e.g. class discussions, student-directed learning (SDL) activities, group learning activities, games, problem-sets, audience-response systems, and in-class written exercises) and think about what they are doing; rather than focusing on rote memorization of facts.

Student engagement. At the core of active learning is student engagement and activity (Warren, 1997). Active-learning techniques engage students more deeply in the process of learning course material by encouraging critical thinking and fostering the development of self-directed learning (Bonwell & Eison, 1991). Proper use of active learning techniques benefit both the students and faculty; by providing opportunities for faculty to assess students' understanding and students have the opportunity to ask questions, and practice skills (Van Amburgh, Devlin, Kirwin, & Qualters, 2006). According to research literature conducted by Chickering and Gamson (1987), in order for students to be actively involved they must be engaged in the hierarchy stages of the learning pyramid (i.e., analysis, synthesis and evaluation).

An increasing plethora of evidence confirms that active engagement significantly impacts student learning, understanding, and critical thinking (Bloom, 1956; Cook-Sather, 2011). Intentional engagement and active learning pedagogies change the nature of learning, while simultaneously improving knowledge gain and recall abilities (Bonwell & Eison, 1991). The evidence universally indicates that students learn best by being actively engaged in the learning process and that students who have higher-order thinking skills have positive experiences and attitudes when exposed to active learning. As opposed to the negative experiences of students who lack higher-order thinking skills (Cook-Sather, 2011; Davis, 2013; Komarraju & Karau, 2008; Machemer & Crawford, 2007; Miller et al., 2013; Miller & Metz 2014).

Learner centered environments. The most essential thing faculty can do to optimize students' learning is to create learner-centered environments (Doyle, 2008). The concept of student-centered learning is generally not definite, within the pedagogic literature but rather frequently associated with constructivism ideals that build on prior knowledge, decisive active learning and critical thinking (Tangney, 2014). Studies on academic performance indicate that student –centered pedagogy and interactive-learning activities increase student performance (Ebert-May, Brewer, & Sylvester, 1997). The view of student engagement is becoming more than just instructional speechmaking (Amburgh et al., 2007), it is a paradigm. Doyle (2008) emphasizes, learner-centered environments require students to elevate further than taking notes and passing exams to embracing new learning roles and responsibilities, in turn, students find the work more interesting and deposit more effort into it (Graffam, 2007).

Allen & Tanner (2005) define active learning as trying to discover undiscovered information, constructing that information in ways that are helpful, and talking through that information with a group. According to Allen and Tanner (2005), this method of instruction promotes student and faculty interactions and encompass a variance of activities and instant feedback; where students are encouraged and given ongoing opportunities to execute their understanding in the classroom. As supported in multiple studies (Bransford, Brown, & Cocking, 2000; Bonwell & Eison, 1991; Davis, 2013; Graffam, 2009; Tangney, 2014) pedagogies that place students at the center of instruction, change the focus from teaching to learning and bolsters learning conditions that are necessary for students to become self-governing critical thinkers; which will elongate students' knowledge and support their comprehensive growth, which leads to a generation of students who are better outfitted to face challenges of a global economy (Bers, Chun, Daly, Harrington, & Tobolosky, 2015).

Findings reported across the board support active learning approaches over lecture (Bonwell & Eison, 1991; Chickering & Gamson, 1987; Cook-Sather, 2011; Davis, 2013; Gregory, 2013; Miller et al., 2013; Miller & Metz 2014; Warren, 1997; Yilmaz, 2014). In a study conducted by Knight and Wood (2005) the advantages of active learning strategies were reaffirmed to support the findings of earlier studies (Weimer, 2015). An experiment investigated whether student learning gains in a large, traditionally taught course in Biology could be increased by making minor changes to the format of the class, to a more interactive format; the same material was presented over two consecutive semesters using altered teaching styles. (Knight & Wood, 2005). During the first semester a traditional lecture format was used however, during the second semester lecturing decreased, student participation increased, in-class cooperative problem solving increased, and understanding of material was promoted and assessed in real-time. Student performance on pretests and posttests were used to compare student learning gains between the two semesters. Not surprisingly, the results indicated moderately higher learning gains and better conceptual understanding in the more interactive course. To solidify the results of the experiment, the study was replicated in 2005, yielding similar results (Knight & Wood, 2005).

Active pedagogical practices such as Problem-Based Learning maximize student learning of course content, and engage both millennial students and faculty at higher levels (Gregory, 2013). In addition, students are given opportunities to apply and demonstrate what they are learning, and to receive immediate feedback (Yilmaz, 2014). Therefore, faculty should meticulously select pedagogical strategies with an emphasis on strategies that endorse selecting, organizing, and integrating knowledge, instead of behavioral activity (Smith & Cardaciotto, 2011). When instructors employ active strategies, more time will be spent facilitating student learning and aiding in the development of their understanding on a deeper level; and less time will be spent transmitting information which equates to surface learning (i.e. traditional didactic lecture (Bonswell & Eison, 1991) which refutes the pedagogical misconception that students learn effectively what they are told in class (Knight & Wood, 2005).

Statement of the Problem

Medical educators are being required to address questions regarding the justification of the current pedagogical practices being implemented in medical classrooms. Medical education has changed little in the past 100 years even in the face of the explosive changes that have occurred in medicine (Prober & Heath, 2012). According to the Flexner Report (Duffy, 2011) medical training is obstinate, unreasonably lengthy and not learner-centered. The expectations placed on medical students can be strenuous, mainly due to the volume of information they are required to digest and regurgitate in much shorter periods of time (Russell et al., 2007). In the first year of medical school the curriculum is concentrated in the biomedical core areas of medicine, which are the foundational science courses and mastery is pertinent to medical student's academic outcomes (Baker, Foster, Bates, Cope, McWilliams, & Musser, 2000).

Despite research supporting the effectiveness of active strategy's such as PBL, which enhance student knowledge and deep learning (Bonwell & Eison, 1991; Chickering & Gamson, 1987; Cook-Sather, 2011; Cook et al., 2010; Warren, 1997; Yilmaz, 2014) medical faculty are reluctant to leave behind the traditional didactic lecture even though, there is less defense of the traditional didactic lecture than there used to be (Miller et al., 2013; Smith & Cardaciotto, 2011; Tsang & Harris, 2016; Weimer, 2015;). Additional findings from multiple studies also indicate that strategies like PBL exalt student learning of course content, and engage both students and faculty at advanced degrees (Gregory, 2013; Hackathorn et al., 2011; Miller et al., 2013; Miller & Metz, 2014; Tsang & Harris, 2016).

Purpose of the Study

The purpose of this study was to review existing research literature on the effect of PBL on medical students' attitudinal behavior, and academic outcomes. Answers to these questions will provide a better understanding of how medical students' attitudinal behavior and academic outcomes have been impacted by the use of PBL beyond course performance. Medical students' attitudes towards PBL curriculums have been the focus of several studies, however the studies have yielded conflicting findings in research literature. Therefore it is necessary to connect and further investigate opposing findings by investigating independent studies that have reported effects of PBL on medical students' attitudes, clinical skills and academic outcomes. Fourteen studies met criteria for inclusion and are included in this investigation. This research builds upon and adds to the existing literature regarding PBL and medical students' outcomes. This research also serves as a resource for medical educators, deans, associate deans and stakeholders as it will provide a more in-depth understanding of how pedagogical practices impact medical students' outcomes as a means to alter the instructional practices that are predominate in the medical environments.

Research Questions

The study examined the following questions:

1. To what extent have medical students attitudinal behavior been impacted by the use of Problem-based Learning (PBL) in medical environments?
2. To what extent have medical students' academic outcomes been impacted by the use of Problem-based Learning (PBL) in medical environments?
3. Does Problem-based Learning (PBL) have a greater impact on medical students' attitudinal behavior or medical students' academic outcomes?

Overview of Methodology

Meta-analysis. According to Petticrew and Roberts (2006) meta-analysis follow a specific sequence: (1) define the research question; (2) determine the types of studies needed to answer research questions (3) conduct a comprehensive search of the literature (4) systematically determine which studies can be included or excluded based on inclusionary criteria (5) critically analyze the included studies (6) synthesize the studies and assess for homogeneity and lastly (7) distribute the findings. Meta-analysis involves statistical pooling of like quantitative research including those found to have various degrees of significance. In meta-analysis, data sets from multiple studies are combined and analyzed for effect size. A standard effect size is first calculated for each of the included studies followed by a calculation of summary effect size generated by pooling effect sizes from individual studies (Petticrew & Roberts, 2006).

As a means of combining inconsistent, contradictory research literature, meta-analysis research provides a number of benefits. Meta-analysis methods provide a controlled and consistent approach for analyzing prior findings in the existing literature, and can answer a number of research questions (Russo, 2007). Meta-analysis findings reveal the biases, strengths, and weaknesses of existing studies. Although meta-analyses are often times conducted to determine the effectiveness of an intervention, meta-analyses are also used to highlight the weaknesses of previous studies and to recommend suggestions for ways to improve the experiment (Russo, 2007).

Limitations of meta-analysis. Although a meta-analysis study is a powerful quantitative technique for synthesizing research, it is not without reproach. Complaints are made regarding the possible hiding or covering up of potential information by only estimating minimal statistical representations across the studies. However, in response to this complaint a meta-analyses assess the distribution effects, which is more than a total or sum of results (Borenstein, Hedges, Higgins, & Rothstein, 2009). Although subjectivity concerns exist meta-analyses are transparent regarding how studies are classified and considered in the review. In following the guidelines established by Glass'; a preexisting pattern for a meta-analysis should follow this order: lay out questions to be examined, gather studies, code the features and outcomes of the studies and analyze associations (Borenstein et al., 2009).

Criticism also arises when studies are compared which should not be compared, since it is difficult to compare effect sizes from studies that vary in methods, and have qualitative characteristics. It is kind of like comparing oranges to apples (Borenstein et al., 2009). For example, this meta-analysis had a comprehensive focus on examining the impact of PBL on medical students' attitudes, clinical skills and academic outcomes therefore, examining kindergarten students' attitudes would be useless. However, Often times in educational research effects for populations with unrelated individuals are considered. But, by linking a magnitude of studies, the researcher can assess study comparability and generalizability, and note inconsistencies that can be monopolized upon to generate future research questions (Russo, 2007).

Publication bias occurs when only published studies are analyzed. When combining p-values gathered from published studies, an upward bias into the effect size can result, thus causing publication bias. Therefore, it is vital when conducting a meta-analysis to be aware that this effect should be reduced significantly, to include unpublished studies to minimize the selection bias (Lipsey & Wilson, 2001).

Delimitations of the Study

To determine the inclusion of studies in this meta-analysis the following guidelines were utilized: design specific to experimental, quasi-experimental or pre-experimental; data presented in study appropriate for meta-analytic calculations; and boundaries for inquiry were decided by negation.

Assumptions of the Study

Meta-analytic results rely on the thoroughness of independent fused studies. Prior study outcomes are assumed to be representative of all studies related to specializations specific to this meta-analysis.

Significance of the Study

Allopathic Medical students are required to pass the United States Medical Licensing Exam and Osteopathic Medical Students are required to pass the Comprehensive Osteopathic Medical Licensing Examination (COMLEX) in order to become licensed physicians (Baker at el., 2000) performed an examination of the relationship of student performance on the COMLEX Level 1; study findings correlate a strong association between academic performance in the first two years of medical School and performance on COMLEX Level 1.

Biomedical Science courses are considered foundational courses for medical school programs and account for the first two years of the program. Clinical courses make up the last two years of the program, and are delivered in a more active format (Cooke et al., 2010). Medical students are required to learn and retain complex biomedical and clinical medicine course content and somehow join together, and correlate them within their own intellect (Russell et al., 2007). Research studies have shown definitively that student academic outcomes are enhanced when active instructional strategies replace the traditional didactic lecture (Bonwell & Eison, 1991; Lenz, et al., 2015; Machemer & Crawford, 2007; Miller et al., 2013; Miller & Metz, 2014; Smith & Cardaciotto, 2011; Warren, 1997). Therefore if the global purpose of medical education is to aid medical students in the development of skills required to teach themselves (Cooke et al., 2010), and to prepare them for the demands of a rapidly growing health care system; it is imperative that medical faculty adopt pedagogical practices that have resulted in improved knowledge, long-term retention, improved clinical skills and better student academic outcomes overall (Donner & Bickley, 1993; Miller et al., 2013). The recent direction toward PBL in medical education equates to the most impactful changes since the Flexner report promoted all-around university alliance (Donner & Bickley, 1993).

Although numerous studies have been conducted in the area of PBL, varied results have created discussion. Many systematic reviews provide compelling data in support of PBL. For example, Zahid, Varghese, Mohammed and Ayed (2016) conducted a study on problem-based learning in comparison to traditional-based learning and PBL showed significant increases in knowledge gains ($P=0.001$) cognitive knowledge and ($p=0.025$) clinical skills. In a systematic review of PBL in undergraduate pre-clinical medical education (Hartling, Spooner, Josvold & Oswald, 2010) thirty unique studies were included. Knowledge acquisition measured by exam scores was the most frequent outcome reported; 12 of 15 studies found no significant differences. Three of four studies found some benefits for PBL when evaluating diagnostic accuracy, and three studies found few differences of clinical (or practical) importance on the impact of PBL on practicing physicians. According to the study evidence does not provide unequivocal support for PBL.

In order to resolve inconsistencies within research literature statistical meta-analysis is designed to integrate findings of multiple studies in order to make sense out of comparisons and contradictions. This study will benefit medical educators, administrators and deans regarding a justification of PBL in medical classrooms, as they work collaboratively to examine, adjust and enhance pedagogical practices currently being used in medical education environments.

Definition of Terms

Key terms defined in this research, are as follows:

- Active Learning: An umbrella term used to represent a variation of teaching techniques and occupies a mass area of research in education. Active learning is an instructional method in which students become engaged participants in the classroom (Bonwell & Eison, 1991).
- Blooms Taxonomy: Created in 1956, by Dr. Benjamin Bloom in order to promote higher forms of thinking in education, such as analyzing and evaluating concepts, processes, procedures, principles, rather than just memorizing facts (Hackathorn at el., 2011).
- Curriculum: The subjects that make up a course of study in an educational institution (Tsang & Harris, 2016).
- Evidence-based Teaching: Is a student-centered small group instructional practice that commission learners to do research, to unite the why and how, and apply knowledge and skills to come up with an applicable solution to a defined problem (Walker, Leary, Hmelo-Silver & Ertmer (2015).
- Instructional Techniques: Strategies used to present information to students and allow learning to take place (Smith & Cardaciotto, 2011).
- Instructional Design: Assigning and inferring the most advantageous instruction strategies for obtaining anticipated changes in knowledge, skills and attitudes of sought after students (Koper, 2006).
- Pedagogy: Involves learning, teaching and development influenced by the cultural, social and political values (Bonwell & Eison, 1991).
- Pedagogical Practice: Instructional techniques and strategies that allow learning to take place (Hackathorn at el., 2011).

- Problem-based Learning (PBL): A student-centered educational approach characterized by the use of real problems as context for students to acquire knowledge and develop skills (Wang, Xu, Liu, Xiong, Xie & Zhao, 2016).
- Traditional Didactic Lecture: A well-ordered, precise method of delivering information to large environments, this method promotes an instructor-centered classroom environment (Richardson, 2007).

Organization of the Study

Chapter 2 provides a review and summary of the literature that examined research relevant to the attitudes and outcomes of medical students regarding the use of an active learning technique known as Problem-based learning. Chapter 3 provides the purpose of the study, research questions, a meta-analysis of the literature, a description of methods used in this research, criteria for inclusion and exclusion of studies in the review, search strategies for identification of relevant studies, search and selection process, and statistical procedures and conventions. Chapter 4 presents a data analysis of studies, research designs, and meta-analysis results. Lastly, Chapter 5 provides a discussion of findings, recommendations for future research, limitations of the current study, and conclusions.

Summary

Chapter 1 is an introduction to the study, which highlighted the statement of the research problem, the purpose of the study, research questions, an overview of the methodology, limitations of a meta-analysis, significance of the study, definition of terms and the organization of this meta-analysis. Chapter 1 also addressed topics that will be discussed throughout the remaining chapters.

Chapter II: Literature Review

Chapter 1 provided an introduction to the study, the statement of the research problem, the purpose of the study, research questions, an overview of methodology, limitations of meta-analysis, significance of the study, definition of terms, a summary and the organization of the study. Chapter 2 provides a review of the literature, which considered the attitudinal behavior, learning preferences, clinical skills and academic outcomes of medical students regarding the use of Problem-based Learning. While numerous studies have shown inconsistencies between how medical students learn best and how medical faculty deliver information, both students (40%) and faculty (29%) agree that active techniques should occupy significant portions of class time (Miller & Metz, 2013).

Although an association between active engagement and positive student outcomes exist, (Armbruster, Patel, Johnson, & Weiss, 2009; Freeman, Eddy, McDonogh, Smith, Okorafor, Jordt, & Wenderoth, 2013; Hackathorn, et al., 2011; Tsang & Harris, 2016) literature surrounding problem-based Learning and its importance in medical environments are incompatible. In any case active engagement is perceived by medical students to be enhanced by instructional practices such as Problem-based Learning (Donner & Bickley, 1993).

Purpose of Study

The purpose of this study was to review existing research literature on the effect of Problem-based Learning on medical students' attitudinal behavior, and academic outcomes. Answers to these questions will provide a better understanding of how medical students' attitudes and academic outcomes have been impacted by the use of Problem-based Learning beyond course performance. Medical students' attitudes towards Problem-based Learning curriculums have been the focus of several studies, however the studies have yielded conflicting findings in research literature. Therefore it is necessary to connect and further investigate opposing findings by investigating independent studies that have reported effects of Problem-based Learning on medical students' attitudes, and academic outcomes. Fourteen studies met criteria for inclusion and are included in this investigation. This research builds upon and adds to the existing literature regarding Problem-based Learning and medical students' outcomes. This research also serves as a resource for medical educators, deans, associate deans and stakeholders as it will provide a more in-depth understanding of how active pedagogical practices impact medical students' outcomes as a means to alter the instructional practices that are predominate in the medical environments.

Research Questions

The study examined the following questions:

1. To what extent have medical students attitudinal behavior, been impacted by the use of Problem-based Learning (PBL) in medical environments?
2. To what extent have medical students' academic outcomes been impacted by the use of Problem-based Learning (PBL) in medical environments?
3. Does Problem-based Learning (PBL) have a greater impact on medical students' attitudes or medical students' academic outcomes?

Problem-Based Learning

Problem-based learning is active learning accelerated by, a clinical, communal scientific problem (Jones, 2006). The trend towards PBL in medical education amounts to one of the most significant changes since the Flexner report synchronized institution affiliation (Donner &

Bickley, 1993, p. 294). Problem-based Learning is a student-centered pedagogical technique that encourages students to manage and master higher-order objectives on Bloom's taxonomy specifically, analysis, synthesis and evaluation (Donner & Bickley, 1993).

After the establishment of PBL in the 1960s, a lot of medical schools started to employ active learning strategies in addition to the passive strategies that were customary, in an attempt to improve the quality of physicians entering the field. The ideology is that PBL techniques yield optimal self-regulation and self-direction on the part of the student, which is a major tenant of medical education (Hartling et al., 2010).

Problem-based Learning curriculums put into place student plans as the muscle that steers and shoulders a system of student-faculty intercommunication in which the student assumes primary responsibility for the process. Orientations of the PBL model are currently being used in a large number of medical institutions. Despite variations of orientations, commonalities of the program include, small-group discussions of biomedical problems, representation of faculty acting as facilitator, and the absence of the traditional didactic lecture (Donner & Bickley, 1993).

"Mixed reviews exist about PBL, mainly because it is a wide ranging term used to relate a lot of concepts with varied meanings. Jones (2006) lists advantages of PBL as follows:

- Making curriculum content relevant by building learning around clinical, community or scientific problems.
- Focusing learning on core information relevant to real scenarios and reducing information overload.
- Fostering the development of valuable transferable skills useful throughout lifelong learning. These include leadership, teamwork and communication as well as problem solving.

- Facilitating trainees becoming responsible for their own learning. This is an essential skill for medical specialists actively engaged in their own continuing professional development throughout their professional lives.
- Increased motivation of trainees to learn by focusing the learning on ‘real-life’ scenarios.
- Encouraging a deep rather than surface approach to learning by forcing trainees to interact with information on multiple levels and to a greater depth than traditional teaching approaches.
- Using a constructional approach to learning whereby trainees construct new learning around their existing understanding.

Although numerous researchers argue for the benefits of PBL, researchers also argue that no single education strategy is perfect for all educational situations and list several disadvantages to PBL: (Jones, 2006).

- The replacement of the traditional teacher role by the facilitator which may make it difficult for trainees to emulate good teachers as role models.
- Teaching faculty being required to facilitate learning rather than to directly impart their knowledge. This may be considered inefficient and, possibly, demotivating to faculty.
- Knowledge acquired through PBL being less organized than knowledge acquired through traditional learning.
- The difficulty of training facilitators and the scarcity of teaching faculty with the skills of facilitating rather than the skills of traditional teaching.

- The time required of trainees to fully engage in PBL. This can be particularly problematic for time-poor faculty and trainees who are being asked to teach and learn within an increasingly crowded curriculum.

Additional disadvantages include the significant costs, resources and time required to train effective facilitators. Problem-based Learning experts also point out concerns about the costs of implementing PBL programs, whilst on the other hand, researchers argue that PBL is not necessarily more expensive than traditional educational approaches and raise the issue of PBL not necessarily covering all areas within a medical topic (Jones, 2006).

This student-centered pedagogy bases learning on real-world problems rather than on specific subjects. The idea behind PBL is to initiate students to acquire information in order to master a problem. In PBL curriculums clearly defined problems, known as cases that give just enough information to activate an investigation are given. Although prior knowledge is needed, the goal of PBL is to ignite students to seek new information to make connections and answer the problems. Students then discuss the problem, record prior knowledge as the group hypothesizes possible solutions and use resources to provide explanations to the problem (Jones, 2006).

The PBL technique uses patient problems as a basis for developing student's problem-solving skills and their knowledge of basic and clinical sciences. Students work in unison to understand a patient's medical problems. Case studies and group learning experiences provide students the structure for PBL and offer model practice for replication through activities that promote high-quality thinking. This student-centered small group learning strategy has been used successfully for more than thirty years and continues to yield favorable results across disciplines (Walker et al., 2005).

Traditional Didactic Lecture

In opposition, the traditional didactic lecture is a well-ordered, precise method to delivering information to large environments however, this method promotes an instructor-centered classroom environment (Richardson, 2007). Minimal changes have occurred regarding this approach to educating students. Lecture halls are packed with students seated, who appear to be learning while the professor is positioned in the front of the room (Mazur, 2009). Traditional didactic lectures as a pedagogical practice continue to face cumulative critique (Mazur, 2009; Kimmel, 1992). Of the reasons supported in this critique is the implication that didactic lectures are less effective as compared to active pedagogical practices when instructional goals involve application, critical thinking skills and positive attitudes (Frederick, 1987; McKeachie, 1994; Newble & Cannon, 1994).

In a study that compared PBL with the traditional lecture-based curricula (Zahid et al., 2016) students in the problem-based learning experience outperformed students in the traditional lecture-based course. The number of PBL students with scores between 80-90% (B average) was significantly higher ($p=0.035$) than that of the lecture group scores ($p = 0.001$), 60-69% (C average). Similarly, the mean multiple choice question (MCQ) and the objective structured clinical examination (OSCE) scores of the PBL students were significantly higher also ($p = 0.001$ and $p = 0.025$). Lastly the traditional lecture group found the theoretical knowledge base (MCQ) to be more difficult ($p = 0.001$) as no variations were related among the PBL group.

There is mounting evidence that suggests the traditional didactic lecture is an ineffective teacher-centered pedagogical practice for promoting conceptual understanding, due to the lack of active engagement (National Research Council, 1999). Research suggests that the exclusionary use of the lecture in the classroom restricts students learning and is a less effective teaching strategy (Bonwell & Eison, 1991). Traditional lecture methods in which faculty talk and students' listen do not place students' in the center of their learning (Bonwell & Eison, 1991).

To the contrary, not all research supports the benefits of active learning, McKeachie (1994) asserts that gauged gains of discussion over lecture are minimal. To test the hypothesis that lecturing maximizes learning and course performance, 225 studies were meta-analyzed (Freeman et al., 2013). The findings reported data on examination scores or failure rates when comparing student performance in undergraduate Science, Technology, Engineering, and Mathematics (STEM) courses under traditional lecturing versus active learning. The effect size indicate that on average, student performance on examinations and concept inventories increased by .047 SDs under active learning (n = 67 studies). The results indicate that examination scores improved by roughly 6% in active learning sections, and that students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning. Findings from the study support the implication that active learning appears effective across all class sizes, which further warrants questions regarding the continued use of traditional didactic lecturing as the control in research studies, and support active learning as the preferred, pedagogical practice (Freeman et al., 2013).

Lujan and DiCarlo (2005) report that although the traditional didactic lecture exposed students to content, that exposure was not sufficient to support learning, since the method only allows an abbreviated amount of time for students to acquire the processing that theorists say is needed for learning to really occur (Bonwell & Eison, 1991; Chickering & Gamson, 1987). To the contrary, some research still supports the implication that a well-structured lecture is one of the most effective ways to integrate and present information from multiple sources on intricate content (Lenz et al., 2015; Richardson, 2007; Smith & Cardaciotto 2011).

As a result, a commonly shared perception among faculty is that the large classroom is exclusive to the traditional lecture but, other literature suggests otherwise (Miller et al., 2013; Bonwell & Eison, 1991; Frederick, 1986; Warren, 1997; Yilmaz, 2014; Cook-Sather, 2011).

Problem-Based Learning versus Traditional Lecture-Based Instruction

Problem-based Learning as originated during the 1950s - 1960s timeframe as a means to improve medical education practices. Although the method is thought of as new, the practice has been around quite some time, however the success of PBL depends extensively on the implementation of the method (Dochy, Segers, Bossche, & Gijbels, 2003). Since the current messages of what represents a traditional lecture-based program is inexplicit so are the perimeters of what is fully representative of PBL. Overall traditional instruction is marked by Didactic large group lectures and instructor-centered learning objectives and practices. According to Dochy et al. (2003) due to the number of representations that make up PBL, a standardized definition is necessary in order for other educational methods to be compared.

Six core characteristics of PBL make-up the model: "the first characteristic is that learning needs to be student-centered. Second, learning has to occur in small student groups under the guidance of a tutor; the third characteristic refers to the tutor as a facilitator or guide. Fourth, authentic problems are primarily encountered in the learning sequence, before any preparation or study has occurred; fifth, the problems encountered are used as a tool to achieve the required knowledge and the problem-solving skills necessary to eventually solve the problem and finally, new information needs to be acquired through self-directed learning" (Dochy, 2003, p. 535). In PBL students rely on their raw knowledge to interlock active learning with their perception and level of importance which they assign to designated subject areas as opposed to the passive style learning which solely hinges upon teacher-designed lectures and instructions

(Dochy et al., 2003). Effective pedagogical techniques provide students with immediate feedback and allow faculty and students to gage their level of understanding instantaneous. Real time solutions to problems (i.e. patient cases) have been shown to facilitate active learning (Dietz & Stevenson, 2011) and have been demonstrated to deliver the real-time feedback necessary to evaluate whether or not the level of student understanding is sufficient.

According to Zahid et al. (2016) an enormous amount of systematic reviews and meta-analyses comparing PBL with the traditional curriculum have been unsuccessful at conveying uncontestable sponsorship in the endorsement of PBL. Although a portion of studies have found PBL to be more beneficial in promoting clinical skills and professional competency, its valuableness in supporting the area of broad knowledge remains uncertain. In a systematic review of active learning (Prince, 2004) reported positive effect sizes in a study that compared cooperative learning to traditional of learning. The reported learning outcomes are consistently positive; academic achievement increased to 0.88, which equates to an increase in student's exam scores from 75-85.

Still, inconsistencies in research have evoked due to an assumption that the PBL curricula lacks homogeneity. Whereas, the lecture has been deemed a more organized way of delivering a curricula (Richardson, 2007). As a result, content heavy curriculums drive faculty to dump an overload of facts, which students commit to memory leaving little time for deep understanding of course material to occur (Brookfield, 2006). When students are given the opportunity to use resources to seek, analyze, and apply information they develop lasting skills (Chickering & Gamson, 1987; Lujan & DiCarlo, 2006). In research conducted by (Haidet, Morgan, O'Malley, Morgan, Moran & Richards, 2014) findings report that when teacher-centered strategies were replaced with learner-centered strategies students' knowledge acquisition improved, but their behavior indicated the session was valued less. Smith and Cardaciotto (2011) investigated student perceptions of active learning, it was hypothesized that students in the active learning condition would report more positive attitudes as a result of the exposure; this hypothesis was not supported. According to Smith and Cardaciotto (2011), it may be possible that students do not appreciate the intellectual effort that is required in active learning activities. It was also suggested that for students who have not reached a certain level of learning as suggested by Bloom, (1956) active learning is like broccoli "although it is good for students intellectually, their overall impression of it may not be completely positive" (p. 58).

Problem-based learning curriculum goals. Problem-based Learning has an all-inclusive foundation as it encompasses cognitive, affective, and psychomotor learning in the teaching and learning process (Demirel & Dagyar, 2015). Problem-based Learning is a practice in which information is mastered in the same framework in which it will be utilized. Problem-based Learning is described as a student-driven process in which the student sets the pace and the role of the instructor becomes one of guide, facilitator and resource. Involvement in medical PBL has been directed by an influential force and that is a need to accommodate the growing volume of knowledge required to practice medicine.

According to Donner & Bickley (1993) the main ingredient in a successful PBL curriculum is the transmittal of an abundance of biomedical facts. "Three foundational goals lead the intent of the PBL curriculum; first the student must have foundational biomedical knowledge equal to that learned most often in a traditional STEM curriculum, especially since the student must be able to apply this foundational knowledge in patient care, as well as an acquisition of attitudes, habits, and techniques that are necessary and must guide continual learning. Second, the student has to do more than depend on rote memorization of facts but instead must apply knowledge gained to solve problems. And lastly, textbooks, literature, references, consultations, and other media sources promote an attitude of ownership and professionalism" (Donner & Bickley, 1993 p. 294).

Attitudes of students concerning problem-based learning. In regards to student attitudes concerning PBL, Demirel and Dagyar, (2015) define attitude as temperaments of perceptions and expressions toward objects or individuals that include psychological ideals; that have a subtle existence in an individual's life and are derived from observable behaviors. In teaching and learning processes, a positive attitude toward course content is regarded as a key component of the affective domain, and students should espouse this attitude. For example, students who have not been exposed to this type of learning environment have neither a negative or positive attitude because they have not experienced the technique first-hand.

Research findings which have investigated PBL's effects on student's attitude toward courses have yielded conflicting results (Lycke, Grottum & Stromso, 2006). Findings from a survey (Messineo, Gaither, Bott & Ritchey, 2007) of undergraduates reveal connections between students' experience level and their perceptions and expectations of large classroom environments. Multiple hypotheses were made, including that students prefer active experiences but expect passive learning experiences, and that experienced students prefer large classes but demonstrate less commitment to them, and lastly, that students view lower level skills as more important than high-level skills in large classes. A number of studies have shown that active learning instructional approaches do lead to improved student attitudes (Marbach-Ad et al., 2001; Mather & Champagne, 2008).

Also in a study conducted by Smith and Cardaciotto (2011) where student satisfaction with active learning activities was evaluated. The 1,091 study participants were enrolled at a large state university. The sample was comprised of 423 male and 640 female undergraduate freshmen which accounted for 71.3% of the class and the authors of this study taught two classes. Each instructor also taught one active learning condition class and one content review condition class which were scheduled consecutively. There were 541 students in the content review condition (CRC) and 550 students in the active learning condition (ALC); there were no noted significant differences in sex or class year. Nine group activities were created by the authors for both conditions. ANOVAS Measures were evaluated with an end-of-semester survey immediately following a final exam, items were rated on a 5-point scale except to measure retention (composite measure a= 0.88), engagement (composite measure a = 0.80) and course attitudes (1 = poor; 5 = excellent), which were all self-reported.

It was hypothesized that students in an active learning condition would (1) report greater retention of course material (2) report more engagement with course material and (3) have more positive attitudes about the course, in contrast to the students who were exposed to content review exercises (i.e. textbook, study guide). The findings were not as hypothesized, instead students held less favorable affective reactions toward active learning conditions than to non-active conditions. Which lends to the inconsistencies that currently exists in research, resulting from faculty's focus on behavioral activity rather than a focus on teaching strategies that move students beyond memorizing and regurgitating facts (Brawer, Lener, & Chalk, 2015; Smith & Cardaciotto, 2011; White, Bradley, Martindale, Roy, Patel, Yoon, & Worden, 2014). Smith & Cardaciotto (2011) communicate eloquently that active learning is good for students intellectually, however their overall impression of it is not completely positive.

According to Lujan and DiCarlo (2006), students must be inspired and taught how to learn, rather than merely given what medical faculty know. When students understand the nature of deep learning and their developmental progress as a learner, they understand the importance of being fully engaged in class activities (Bers et al., 2015; Lujan & DiCarlo, 2006; Powell, Cleveland, Thompson & Forde, 2012). When classroom activities are passive and not well designed or executed students are unwilling to engage (White et al., 2014). Studies also revealed that, deeply engaged students feel apparent and responsible (Graffam, 2009; Mather & Champagne, 2008).

In a study of students' satisfaction and academic performance with PBL in an epidemiology and health demographics course (Mejias, Prieto, Ruiz, Porcel, Moleon, & Claret, 2015) findings confirmed the usefulness of PBL as a strategy that increased student satisfaction. The aim of the study was to evaluate the effect of PBL on university students' satisfaction with and academic performance in a course on epidemiology and social and demographic health. Participants in the interventional study included 529 third-year medical students enrolled during 2010 – 2012; 272 students were assigned to the intervention group and 257 students were assigned to the control group. Interventions consisted of utilizing a list of problems specifically designed and adapted to PBL methods for small-group study during practical sessions. In the 5 credit course practical exercises were divided into 10 sessions taught during a two week period.

Following the session's students' satisfaction with the two teaching strategies was evaluated with an anonymous questionnaire that aimed to compare the units, the questionnaire items were chosen from the Teaching Evaluation Questionnaire for student participation. The instrument was recognized as a validated tool to assess university-level students in Spain. Differences between groups in the distribution of responses to the satisfaction questionnaire were sought with the chi-squared test and multiple regression models. Student's t test for independent samples was used to highlight differences between groups in total score on the satisfaction questionnaire and exam score. On the satisfaction questionnaire the intervention group score (10.6) was significantly higher than in the control group (9.4, <0.001). The mean exam score was also significantly higher among the intervention group (7.1, standard deviation = 1.6) than that of the control group (6.5, standard deviation = 1.6. $p<0.001$). The results are consistent with findings from like studies that evaluated students' satisfaction and academic performance when exposed to PBL (Emerald, Aung, Han, Yee, Myint, Soe, & San, 2013; Hagi & Al-Shawwa, 2011; Khan, Taqui, Khawaja & Fatmi, 2007).

This study confirms the association between the use of active learning techniques like PBL and greater student satisfaction. Most important, this study supported the implication that PBL not only positively influenced students' satisfaction but as a result of their improved satisfaction, improvements in academic performance were noted. The study results also support the need to extend PBL as a learning technique to other areas in the course plan in medicine degrees as well as to other areas in university-level health science education and training (Mejias et al., 2015).

Learning styles and problem-based learning. A major tenant of education is to help students become effective learners. In a study conducted by Cebeci, Dane, Kaya and Yigitoglu (2013), both law and medical students preferred a deep and strategic approach more than a surface approach to learning; medical students chi square = 55.874, $p<0.001$/ and law students chi square = 72.991, $p<0.001$. Thus indicating that both law and medical students are deeply motivated for achievement. Therefore, having an understanding of learning styles can help an individual learn more efficiently (Silver, Strong & Perini, 1997).

According to Balasubramaniam and Indhu (2016), medical students have a wide range of diversity in their learning preferences, which is an ongoing challenge for faculty attempting to meet the needs of all students. Learning styles/preferences are defined as “stable traits that influence a learner’s information processing and thus his cognition in terms of attention, perception and thinking. They even influence a person’s learning behavior in groups, problem solving, and interaction with educators” (Shukar, Zainab & Rans, 2013 p. 25).

In a study of learning style preferences among first-year medical students (Balasubramaniam & Indhu, 2016) investigated the learning styles and approaches to learning among the first-year students in a tertiary care teaching hospital using the (VARK)Visual, Aural, Read/write and Kinesthetic way of learning styles questionnaire 7.8 version. The VARK is a learning inventory tool classified as an instructional preference model. The model categorizes learning by sensory preferences, for example students’ preferences fall into one or more of the categories: (V) = pictures, graphs, flowcharts (A) = lectures, tutorials (R) = reading and taking notes (K) =connect reality and acquiring information through experience and practice.

The questionnaire was completed by 144 students and findings revealed that the majority of medical students had a learning preference that fell into the category of (K) kinesthetic 35% and (A) auditory 34%, thus indicating that the first-year medical students in this study preferred to be involved in a classroom experience that allowed them to connect reality, acquire information through experience and practice in combination with lecture and tutorial. Problem-based Learning classroom environments afford students the opportunity to be exposed to small amounts of lecture and the concrete experiences that they are seeking (Balasubramaniam and Indhu, 2016).

According to Shukar et al. (2013) preferred learning styles tend to vary, since how we acquire knowledge, skills and attitudes vary from individual to individual. However, identification and evaluation of an individuals preferred learning style can yield lucid advantages. A study by Gadt-Johnson and Price (2000), revealed that Learning Styles (LS) symbolize an individual learner's tendency to learning certain material and concluded that a powerful relationship exists between student's unique learning style and their academic success. Equally important is the instructor's capability to vary pedagogic strategies based on the needs of the students (Cuthbert, 2005). Since active learning techniques affect learning on deeper levels. Instructors who vary their presentation methods create extra learning opportunities for students with different LS (Cook & Hazelwood, 2002).

Bhagat, Vyas, and Singh (2015) define LS as "the composite cognitive, affective, and physiological characteristics that are relatively stable indicators of how a learner perceives, interacts with and responds to the learning environment" (p. 58). Numerous researchers are in agreement that students learning experience is enhanced when material is delivered in a manner that complements their learning style (Gardner, 1985; Griggs, 1985; James & Maher, 2004; Kolb, 1984; Shukar et al., 2013; Slavin, 2000).

To take an even deeper look into the learning preferences of preclinical medical students enrolled in an Army Medical School, Saga, Qamar and Trali (2015) conducted a descriptive study. Participants were students in the Department of Anatomy and the duration of the experiment ranged from April 2015 to June 2015. Of the 400 undergraduate students invited to participate in the LS preference exercise 294 (73.5%) consented to provide demographic information, and responses to the questionnaire. Of the 294 students 159 (54.1%) were male and 135 (45.9%) were female. The assessment tool consisted of 16 questions with 4 options each. The score for each VARK section of the study population was added up and divided by the total amount of study participants to gather mean scores. A p-value of less than 0.05 was taken as statistically important.

The results indicated that among the 294 students, 153 (52%) had a unimodal= multi-modal LS preference, which was the largest one and among the unimodal=multi-modal group 34% of the students were auditory learners and 35.9% were kinesthetic learners. During the second phase of the study data was collected and calculated in an attempt to identify principal learning styles and as a result learning approaches were advised. What was apparent in the results of the study was the need for course outlines to consider altered prospects to address and accommodate students who encounter academic difficulties better than those who matriculate through more traditional classroom environments. Findings from the study strongly suggest that most emerging learners prefer a multi-modal approach to learning (Saga et al., 2015).

The findings of this study were comparable to the results of earlier studies and support the research in this meta-analysis regarding the need for pedagogical practices that meet the altered needs of students who make up the medical classroom (Gardner, 1985; Griggs, 1985; James & Maher, 2004; Kolb, 1984; Slavin, 2000; Shukar et al., 2013).

In other studies, Gurung, Chick, and Haynie (2009) and Chick, Haynie and Gurung (2012) investigated how 29 unassociated and integrative fields cultivate deep learning and guide students thinking in a manner parallel to disciplinary experts. The Carnegie Foundation for the Advancement of Teaching (2006) also conducted a set of relative studies that investigated how members of different professions (i.e. clergy, 2005; lawyers, 2007; engineers, 2008; nurses, 2009; and physicians, 2010) are educated for their duties in the communities they serve. Ultimately, these studies revealed what faculty seemingly already know, and that is that these students need to learn more than basic content; faculty want students to understand and practice disciplined ways of thinking also (Chick et al., 2009).

Research by Messineo et al. (2007) also explored the preferred learning styles of students in relation to teaching style and professor expectations. The findings revealed a variation between the way students learn best (i.e. active strategies) and the preferred method of instruction (i.e. passive strategies) by instructors, which do not align with the preferred learning styles of the students, who were third year science and medical students.

When it comes to establishing the utility of learning styles for medical students, two issues are emergent according to Feeley (2015). First, researchers are yet to spell out specifically what hidden ideas are weighted by the copiousness of LS tools available and second a number of researchers also question whether LS are a mere figment of the imagination (p. 238). The findings of a critical review of LS versus learning approach Feeley, (2015) confirmed that even though LS do not bridge a partnership with exam performance, learning approaches do. Students with strategic and deep approaches to learning perform routinely better on examinations (Cebeci et al., 2013). Current evidence shows that aiding students in the progression of their individual factual learning approach is more effective (and more attainable) than striving to alter students LS. Investigation outcomes, will aid medical educators hoping to help medical students succeed academically, the wrap-up results were factual for both traditional and graduate-level medical students (Feeley, 2015).

Student achievement concerning problem-based learning.

Since PBL requires students to conduct research, integrate theory and practice, and discover practical solutions to well-defined problems by utilizing their knowledge, it is classed a clinical skill (Borrows, 2002). He describes PBL as an approach that provides research experiences in the area of education to enrich students' knowledge through learning, team work, content exposure and discipline. In addition, PBL delivers knowledge and diagnostic skills by providing concrete learning situations in addition to teaching. In measuring academic performance, between two programs that measured two approaches to learning, PBL and traditional; Lycke et al. (2006) reported significant differences between students exposed to PBL and students exposed to traditional learning. Problem-based Learning students reported more engagement ($p = 0.04$), construction of knowledge ($p<0.001$), and stimulating education ($p = 0.001$) thus indicating that PBL students find it important to seek, and analyze material and form their own knowledge more than traditional students. However for short term there was no significant difference in test scores between the groups ($p = 0.79$). Literature supports the theory that active pedagogies like PBL promote long term learning by providing more than subject knowledge but go a step further and teach students how to acquire the skills necessary to transfer that knowledge, in contrast to passive pedagogies that expose and often times overload students with only specific course content (Feeley, 2015).

Links between academic outcomes and problem-based learning. Studies of student learning strategies imply a measure of individual symmetry, however students seem to attempt to adjust their strategies to the learning condition. Therefore, the outcome of student inclined learning environments have for example been exhibited to enlarge over time with students in student-friendly courses accounting for more self-regulation than students in traditional courses (Lycke et al., 2006).

Kelson and Distlehorst, (2000) state “Problem-based Learning outcomes should be discussed on a broad basis including a useable knowledge base, skills in problem solving, self-directed learning and collaboration” (p. 717). According to Schmidt, Harter, Killham & Agrawal, (2009), effects of PBL as reported in curriculum divergences have been shown to be inconsistent over different medical schools. Findings demonstrate that curriculums which take into account how knowledge and understanding is generated by experience can have positive effects on learning. However these findings are at discord with assumptions expressed in other literature. In a meta-analysis conducted by Walker & Leary (2009), studies were categorized by the types of problems used, the PBL approach employed and the level of assessment, across the 82 studies and 201 outcomes the findings favor PBL (d =0.13,=/-.025).

The findings from *Problem-based learning in pre-clinical medical education: 22 years of outcome research*, (Hartling, Spooner, Josvold & Oswald, 2010) did not provide undisputable support for improved learning outcomes through PBL. Five studies evaluated the effectiveness of PBL within the course or topic. The trials were at risk of bias due to non-randomization that varied by study. However even the one study that was a randomized trial found no significant differences in knowledge in terms of overall academic assessment. Despite the leading findings it is important to note that PBL students had a richer learning experience. Results from the study revealed that PBL did not impact knowledge acquisition, and its impact in other areas was questionable, thus warranting further investigation. A major contributor of the varied results among studies could be attributed to the methodological weaknesses and heterogeneity among the studies in this meta-analysis (Hartling et al., 2010).

Three studies included in the meta-analysis yielded inconsistent findings as well. Hinduja, Samuel & Mitchell, (2005) found significantly better exam scores for traditional students (37/50 SD=3.91 versus 32.35/50 SD=4.9, $p<0.001$. Casassus, Hivon, Gagnayre & d'Ivernois, (1999) found no difference in knowledge acquisition between PBL and traditional students; although PBL students yielded better problem-solving skills. Lastly, Sivam, Latridis & Vaughn, (1995) found that students from the traditional curriculum were at or below the national average on a standardized exam while PBL students performed at or better than the national average. Other findings also report improved scores on National exams when students were exposed to active pedagogies (Kelson & Distlehorst, 2000).

Researchers (Mennin, Heimberg, Turk & Fresco, 1993) suggested a hybrid program that provides more structured learning early in the curriculum with a slow increase in active and self-directed learning may provide a better intervention. In response, Al-Drees, Khalil & Irshad (2015) conducted a study of students' perception towards the problem based learning tutorial session in a system-based hybrid curriculum. The study found that students felt the PBL sessions were beneficial in their learning process (mean: 3.84/0.90); 84.4% of the male and 75.6% of the female students reported that the PBL sessions were helpful in understanding science concepts. The assumption that PBL techniques yield both positive understanding and positive execution by involving students, through self-direction and problem solving is supported across numerous studies (Hartling et al., 2010; Lycke et al., 2006; Walker & Leary, 2009).

According to data collected by Mazur (2009) data supported the implication that learning rewards almost triple when teaching strategies focus on the student and interactive, collaborative learning. Barr & Parrett (2003) say "teacher quality is the most influential factor in student achievement" (p. 15). This declaration is perhaps the most important component suggestive of an effective teacher. Active learning has proven to be a powerful predictor of positive student outcomes (i.e. course grades, test scores, and an increase in medical school retention rates (Baker et al., 2000; McLaughlin et al., 2014). Time and time again research literature reported a mutual relationship between active learning and positive student outcomes (Bonswell & Eison, 1991; Chickering & Gamston, 1987; Graffam, 2007; Lenz et al., 2015; Miller et al., 2013; Miller & Metz, 2014; Warren, 1997).

Clinical skills and problem-based learning. Problem-based Learning utilizes clinical cases to promote inquiry, critical thinking and knowledge application/integration related to the sciences; biological, behavioral and social basic to medicine. The work backwards design is endorsed by teaching and learning scholars (Fink, 2003). The design takes on a holistic approach to overall diagnosis, and patient treatment, by working backwards from abstract to concrete since it is fundamental to have a well-defined logic of the intended outcomes. In other words necessity of skills, assessments, assignments, and objectives should be planned with what one hopes to accomplish at the forefront of the process (Martinez, Vega, Wells, Mora, & Gillis, 2015). Through this active cooperative, case-based learning process students gain a deeper understanding of the principles of medicine but more importantly gain the skills necessary for life-long learning (Garcia, Ginsburg, & Voth, 2017).

Instructional Changes

According to a cross-sectional study conducted by McLaughlin et al. (2014), fostering relevant learning is a dual responsibility between the student and the instructor and by creating new solutions, academic mastery can be achieved to better prepare students for their specialties.

An empirical study on active teaching techniques investigated the effectiveness of four teaching techniques (1) the lecture, (2) demonstrations, (3) discussions and (4) in-class activities used in the classroom (Hackathorn et al., 2011). The findings of the study revealed that although each technique provided different advantages for students, as each technique aided in different levels of learning. The in-class activities emerged as the teaching strategy that led to higher overall scores than any of the other teaching strategy and the lecture led to the lowest overall scores of any of the teaching strategies, thus supporting the implication that student-centered pedagogies are superior to instructor-centered pedagogies that do not place students at the center of their learning.

According to Graffam (2009), “Transforming medical pedagogy is a necessary step for improving learning environments in medical education” (p. 38). Understandably, the overhaul of teaching practice is difficult since it encompasses more than just changing classroom practices, it is also necessary to perform a personal inspection of views, specifically those regarding learning. In regard to beliefs that deter teaching modifications, many faculty: “regard the adaptation of instructional practices as equivalent to lessening academic quality; believe that teaching is transferring knowledge from one person to another; and believe their job mandates covering all pertinent and available material” (p. 39).

Yet, research portray these beliefs to be disadvantageous to quality learning (Bonwell & Eison, 1991; Bransford et al., 2000). Although many instructors in post-secondary settings presume they promote critical thinking and active learning, in reality only 9% take on these activities on an ongoing basis and only 8% can identify active learning in practice (Graffam, 2009). These same instructors give an account of the positive nature of their lectures when, in reality, lectures take up a disproportionate amount of class time (Fink, 2003), do little to make certain that content material is well learned, and offer information in a unique fashion when evidence points to a broad range of learning styles among students in higher education, including medical schools (Graffam, 2009). “A majority of educators within medical education employ teaching methods that knowingly fail to change physician behavior and thus cannot be expected to improve the quality of care physicians provide to their patients” (Graffam, 2009, p. 41). To address this situation, pedagogical conversions are needed.

Faculty members who are contented with their traditional style of lecturing continue to be unconvinced that more active teaching strategies like PBL will lead to a much deeper understanding and application of course content; most are even doubtful of the feasibility of active learning implementation in the large classroom (Allen & Tanner, 2005). A pedagogical reformation is justifiably a challenge for medical faculty, since many of them were also instructed explicitly through the use of passive, instructor-centered pedagogies (Silverthorn, Thorn, & Svinicki, 2006) and have had little to no exposure to other teaching strategies (Graffam, 2009).

Active learning pedagogical practices have been validated in numerous studies as a more effective way to increase student learning (Amburgh et al., 2006; Bonwell & Eison, 1991; Cooke et al., 2010; Doyle, 2008; Duffy, 2011; Gregory, 2013; Miller & Metz. 2014; Russell et al., 2007; Warren, 1997;). Therefore, Medical faculty need to make changes in their historical pedagogical practices (Cooke et al., 2010; Graffam, 2007). There is a generalized agreement that PBL affords a more rigorous, encouraging, pleasing approach to education than conventional approaches (Hartling et al., 2010; Lycke et al., 2006; Walker & Leary, 2009).

Summary of Literature

Chapter 2 reviewed literature surrounding active learning and described the fundamental purpose of medical education, which is to assist medical students in the development of skills required to teach themselves (Cooke et al., 2010). The literature supports the ideology that active learning and active learning teaching pedagogies like PBL lead to improved student outcomes. Studies investigating the impact of PBL on medical students' achievement revealed favorable results regarding outcomes and attitudes. However, despite beneficial, positive, student outcomes, literature suggests that faculty are slow to abandon passive, teacher-centered teaching strategies currently being used in medical environments for more active techniques like PBL. Despite conflicting evidence this review of literature adds to the current research on measures that are needed to systematically integrate PBL into medical education curricula. For example, measures that will be reflective of factors that yield improved practice and quality outcomes of patient care (Hartling et al., 2010).

Chapter III: Methods

Chapter 3 includes the purpose of the study, research questions and a description of the methodology used in this study which is a meta-analysis. The philosophical relevance will be described to include philosophical constructs for interpretive and reaction variables. Approaches to collecting data, criteria for the exclusion of inappropriate data and coding of studies will also be discussed.

Opposing results among studies with similar topics within the realm of education often times arise. Distinctions among environments, quality of treatment, methods and instruments muddle associations. Glass (1976) designated an approach for solving opposing results in research. According to Glass (1976), "meta-analysis refers to the analysis of analyses… the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings" (p 3). Meta-analysis are systematic quantitative techniques that allow the researcher to effectively summarize results and quantify dispersion across multiple studies (Drowns & Rudner, 1986). The initial power of meta-analysis rests in its usage of effect sizes. However, the initial weaknesses of meta-analysis rests in its dependence of the exactness of the main research (Christman, 1995). The translation of empirical research findings to this common metric allows comparison of results amidst multiple studies (Penuel et al., 2002).

Studies of PBL contain recurrent oppositions and inconsistencies. However, the mutual connection in these studies is the overall goal of analyzing the attitudes, knowledge, and the skill set of medical students. Philosophical associations of interest are medical students' attitudes toward PBL and medical students' academic outcomes when PBL is used as an instructional method. DeCoster (2004), lists the following as reasons for analyzing the effects from the massed studies: "(1) establish the presence of an effect, (2) determine the magnitude of an effect, (3) resolve differences in a literature, and (4) determine important moderators of an effect" (p. 4).

Expository variables assist in the paradoxical explanation of associations in meta-analyses. For example, in this meta-analysis an expository variable may occur regarding students' ratings of faculty. If group 1 was taught a concept actively (active learning strategy) by a faculty member that had never taught actively and group 2 was taught the same concept actively (active learning strategy) by a faculty member who had been teaching this concept actively for several years; the students' in group 2 are likely to respond with a more favorable attitudinal rating for the experience than students in group 1.

Purpose of the Study

The purpose of this study was to review existing research literature on the effect of Problem-based Learning on medical students' attitudinal behavior, and academic outcomes. Answers to these questions will provide a better understanding of how medical students' attitudinal behavior and academic outcomes have been impacted by the use of Problem-based Learning beyond course performance. Medical students' attitudes towards Problem-based Learning curriculums have been the focus of several studies, however the studies have yielded conflicting findings in research literature. Therefore it is necessary to connect and further investigate opposing findings by investigating independent studies that have reported effects of PBL on medical students' attitudinal behavior, clinical skills and academic outcomes. Fourteen studies met criteria for inclusion and are included in this investigation. This research builds upon and adds to the existing literature regarding Problem-based Learning and medical students' outcomes. This research also serves as a resource for medical educators, deans, associate deans and stakeholders as it will provide a more in-depth understanding of how pedagogical practices impact medical students' outcomes as a means to alter the instructional practices that are predominate in the medical environments.

Research Questions

The study examined the following questions:

1. To what extent have medical students' attitudinal behavior been impacted by the use of Problem-based Learning (PBL) in medical environments?
2. To what extent have medical students' academic outcomes been impacted by the use of Problem-based Learning (PBL) in medical environments?
3. Does Problem-based Learning (PBL) have a greater impact on medical students' attitudinal behavior or medical students' academic outcomes?

Participants

This research examined PBL and its effect on the attitudinal behavior and academic outcomes of a representative sample of medical students in medical environments. The data were obtained from 14 independent studies on 4,918 medical students across numerous medical schools. Respondents included a nationally representative sample of male and female medical students, (medical student is defined as enrolled in a medical school), exposed to PBL as a pedagogical practice.

Literature Search

Limits were set as a means to include and exclude research studies. Studies were considered for inclusion if the study resulted in effect sizes or statistics that could be converted to effect sizes. Articles related to academic outcomes and attitudinal behaviors of medical students' use of PBL were included. Studies that were qualitative (to include anecdotal) in nature were excluded due to the statistical analysis required for meta-analysis. Educational environments outside of medical education environments and education programs outside of medical education were also excluded.

An extensive effort was made to gather both published and nonpublished research studies on the subject of academic and attitudinal outcomes for medical students' use of PBL. The literature search encompassed using the following seven databases; Auburn University Theses and Dissertations (AUETD), ERIC, ERIC (Ebsco), Education Research Complete, Google Scholar, Medline (Ebsco), ProQuest Dissertations and Theses, and PubMed. In addition AUED and ProQuest were also searched for potential unpublished/grey literature. Database searches were conducted without confines as to languages, dates, or category of source.

Keywords searched for Problem-based Learning, active learning, Problem-based Learning techniques, medical education, medical school, attitudinal behavior, academic achievement, academic outcomes, and clinical skills in PBL. Studies were selected as general interest areas: Search terms for this meta-analysis successfully located studies related to the research topics; medical education, medical settings, medical classroom, PBL in medical education and medical student academic outcomes. Subject terms that returned database results pertinent to PBL as active learning technique and medical education included osteopathic, allopathic, PBL techniques, medical classroom, medical students, and preferences and attitudes. The use of these phrases were necessary to narrow and eliminate the amount of studies that involved K-12 population and educational environments. To locate studies for selected population osteopathic, allopathic, medical education, medical school, professional school, and pre-med was selected if available within each database. (see Appendix A Engagement Search Terms by Database). The most common method used in research that assessed the attitudes, perceptions, and academic outcomes of medical students' were qualitative in nature, which eliminated the inclusion of numerous studies. Comparisons between types of behaviors (experimental; intervention) in addition to control groups are included in this review. The outcomes of these studies are often times treated as dependent variables. A number of studies that were located provided multiple measures of efficacy, performance, knowledge, skills, and attitudes for example: student satisfaction, student perception, student learning and self-efficacy.

Criteria for inclusion and exclusion. The following criteria were used to determine inclusion status or exclusion status of studies to be included in the review for purposes of evaluating the impact of PBL, attitudinal behavior and academic outcomes regarding PBL as a teaching technique used in medical environments. Studies were identified and examined to distinguish their congruence within the inclusion criteria. Titles and abstracts that addressed topics other than the topics listed above were eliminated. Multiple study characteristics were used as criteria for inclusion. Studies that were included evaluated: PBL as an active learning technique, PBL in medical classrooms and settings, clinical skills, attitudinal behavior, perceptions, and academic outcomes. If the characteristics of studies and abstract contents were not clear, the studies were analyzed with focused attention, after which studies were eliminated if the inclusion criteria were not met. Studies that yielded relevant information were retained.

Coding of studies. A form was utilized to arrange study information and establish relevant categories to assist in systematic coding. The document, Quality Assessment Tool for Quantitative studies. The tool contains 43 items divided into four key areas (data sources, analysis of individual studies, meta-analysis methods, and interpretation), each of the key areas has a summary question to provide a summarization (Higgins et al., 2013). Demographics, student outcomes, attitudinal behavior, knowledge/learning, clinical skills, and reliability and validity characteristics were gathered in a systematic manner by utilizing this form. (see Appendix C Detailed Data Extraction Form)

Summary

This study was a meta-analysis across fourteen independent studies, which analyzed the impact of PBL on students' attitudinal behavior and student's academic outcomes. Quantitative, statistical measurements are representative of the combined findings across all studies included in the meta-analysis. Chapter 3 included a description of the methodology used in this study. The philosophical relevance was described and discussed to include philosophical constructs.

The purpose of the study, research questions, approaches to data collection, criteria for the exclusion of inappropriate data and coding of studies was included in this methods section. The methods used to analyze the data for the purpose of the present research were consistent with some previous literature on this topic. All of the independent variables were analyzed for their effect to the dependent variable of Problem-based Learning. Chapter 4 will provide an analysis of results for each of the research questions proposed.

Chapter IV: Findings

This chapter contains a statistical analysis of attitudinal outcomes, and a statistical analysis of academic outcomes. Philosophical affiliations of interest will be investigated for the presence of a statistically significant effect, the magnitude of that effect, and differences related to studies; sources of research will also be discussed. The coding of studies and effect sizes will be computed with the goal of clarifying the true nature of the muddled affiliations involved among the variables. This chapter also contains the results of the data analysis, and an analysis of each research question follows.

Purpose of the Study

The purpose of this study was to review existing research literature on the effect of Problem-based Learning on medical students' attitudinal behavior, and academic outcomes. Answers to these questions will provide a better understanding of how medical students' attitudes and academic outcomes have been impacted by the use of Problem-based Learning beyond course performance. Medical students' attitudes towards Problem-based Learning curriculums have been the focus of several studies, however the studies have yielded conflicting findings in research literature. Therefore it is necessary to connect and further investigate opposing findings by investigating independent studies that have reported effects of Problem-based Learning on medical students' attitudes, and academic outcomes. Fourteen studies met criteria for inclusion and are included in this investigation. This research builds upon and adds to the existing literature regarding Problem-based Learning and medical students' outcomes. This research also serves as a resource for medical educators, deans, associate deans and stakeholders as it will provide a more in-depth understanding of how pedagogical practices impact medical students' outcomes as a means to alter the instructional practices that are predominate in the medical environments.

Research Questions

The study examined the following questions:

1. To what extent have medical students' attitudinal behavior been impacted by the use of Problem-based Learning (PBL) in medical environments?
2. To what extent have medical students' academic outcomes been impacted by the use of Problem-based Learning (PBL) in medical environments?
3. Does Problem-based Learning (PBL) have a greater impact on medical students' attitudinal behavior or medical students' academic outcomes?

Criteria for Inclusion

Research literature had to meet established criteria for inclusion. Research studies that produced effect sizes or statistical data that yielded effect sizes and concerned PBL, medical student academic outcomes, or medical education were included. Research studies (77) yielding only percentage results with the absence of effect sizes, sample sizes, a mean and standard deviations were excluded. Studies in relation to educational settings outside of medical educational settings, and students not defined as being enrolled in medical school were excluded. Case study projects qualitative in nature (46) were excluded, and a number of studies were not accessible (29).

Coding of Study Characteristics

The Quality Assessment Tool for quantitative Studies was used as a means to code studies (see Appendix B). Information was gathered in relation to demographic, student, teaching strategy, academic outcome(s), reliability and validity. (See Table 1).

- Demographics included educational environment type; student sample size and number of schools.
- Student characteristics involved types of behavioral measures (attitudinal) and academic outcomes (knowledge; skill-set)
- Instructional characteristics active/passive teaching strategies, setting, mode of instruction, regulated learning.
- Statistical characteristics of each study focused on reliability and validity.

Table 1

Descriptive Statistics for Articles

			Control Attitude		**Experiment Attitude**		**Control Knowledge**		**Experiment Knowledge**	
Author	**Year**	**Setting**	**N**	**M (SD)**	**N**	**M (SD)**	**N**	**M (SD)**	**N**	**M (SD)**
Nanda	2013	Medical School	0	0 (0)	0	0 (0)	55.4	0.6 (0.3)	133	1.1 (0.3)
Khan	2007	Medical School	32	60.7 (27.2)	43	77.5 (14.6)	32	58.4 (17.3)	43	58.4 (20.1)
Al.Drees	2003	Medical School	275	3.9 (0.9)	275	3.5 (0.92)	275	3.9 (0.9)	275	4.0 (0.9)
Emerald	2013	Medical School	49	50.4 (0)	49	66.81 (0)	49	46.4 (0.0)	49	46.9 (0.0)
Tucker	2009	Medical School	70	75.0 (6.8)	70	75.2 (8.56)	70	75.8 (7.2)	70	76.1 (6.8)
Kuhnigk	2012	Medical School	987	1.7 (0.8)	971	3.0 (1.3)	1020	1.4 (0.7)	1016	1.5 (0.7)
Hagi	2011	Medical School	250	3.6 (1.1)	256	3.7 (1.04)	250	3.6 (1.1)	256	3.9 (0.9)
Gowrishankar	2015	Medical School	10	23.5 (1.8)	10	26.5 (2.2)	10	5.2 (2.6)	10	6.4 (1.0)
Keller	2010	Medical School	26	14.9 (3.0)	12	9.7 (2.7)	26	22.2 (5.5)	12	28.9 (6.1)
Lucieer 1	2016	Medical School	111	23.5 (0.0)	66	23.8 (0.0)	111	33.7 (0.0)	66	33.9 (0.0)
Lucieer 2	2016	Medical School	111	23.5 (0.0)	66	23.8 (0.0)	111	33.7 (0.0)	66	33.9 (0.0)

Lucieer 3	2016	Medical School	139	23.5 (0.0)	68	24.7 (0.0)	139	31.5 (0.0)	68	34.1 (0.0)
Latif	2014	Medical School	92	23.5 (5.3)	106	21.6 (4.5)	69	9.4 (3.2)	58	8.0 (2.4)
Mejias	2015	Medical School	257	6.5 (1.6)	272	7.1 (1.6)	0	0.0 (0.0)	0	0.0 (0.0)

Note: N=sample size; M = Mean; SD = standard deviation; 0 = not reported by author

Calculation of Effect Size

To quantify the size of an effect, included studies should report effect sizes directly, or statistics necessary to calculate effect sizes. Effect sizes fall into two groups: measures of group differences and measures of association. Common measures of group differences are Cohen's *d* Hedges, *g*, or Glass' Δ (Ellis, 2010). To calculate group difference measures, the minimum required statistics include means and standard deviations. For example when aggrandizing the extent of an effect size, .2 is indicatory of a small effect, .5 of a moderate effect, and .8 a strong effect. However, it is suggested that researchers reference what is common under reciprocal circumstances before assigning values to effect sizes (Glass, McGaw, & Smith, 1981). Studies that did not report a standard deviation, but did report standard error and sample size, were also included, as it is possible to calculate the standard deviation from the standard error and sample size. Alternately, *F*-statistics and *t*-values can be used in conjunction with sample sizes to calculate group difference effect sizes. In order to properly weight studies and determine precision via confidence intervals, studies should provide a sample size. As this meta-analysis included a variety of study designs, studies that reported measures of association as effect sizes were also included. Measures of association include correlation indices, such as Pearson's *r*, or proportion of variance indices (Ellis, 2010). (see Table 2).

Results

A sample of 4,918 medical students across 14 independent studies, were analyzed for this meta-analysis. The mean effect size for the control group was 23.6 the mean effect size for the experimental group was 24.5. Data entry and analysis was carried out utilizing Statistical Package R: A Language and Environment for Statistical Computing (R Core Team, 2016). This software was used to measure the impact of PBL on medical students' attitudes and academic (knowledge) outcomes. The quantitative data were presented in the form of means and standard deviations. Significance is considered at p-value less than <0.05.

Table 2

Attitude and Knowledge Effect Sizes.

Author	**Year**	y_A	y_K
Nanda	2013	-	-1.83
Khan	2007	-0.80	0.00
Al.Drees	2003	0.41	-0.17
Emerald	2013	-	-
Tucker	2009	-0.03	-0.04
Kuhnigk	2012	-1.21	-0.14
Hagi	2011	-0.10	-0.29
Gowrishankar	2015	-1.42	-0.56
Keller	2010	1.74	-1.15
Lucieer 1	2016	-	-
Lucieer 2	2016	-	-
Lucieer 3	2016	-	-
Latif	2014	0.39	0.50
Mejias	2015	-0.37	-

Note: y_A = Attitude effect sizes; y_K = Knowledge effect sizes

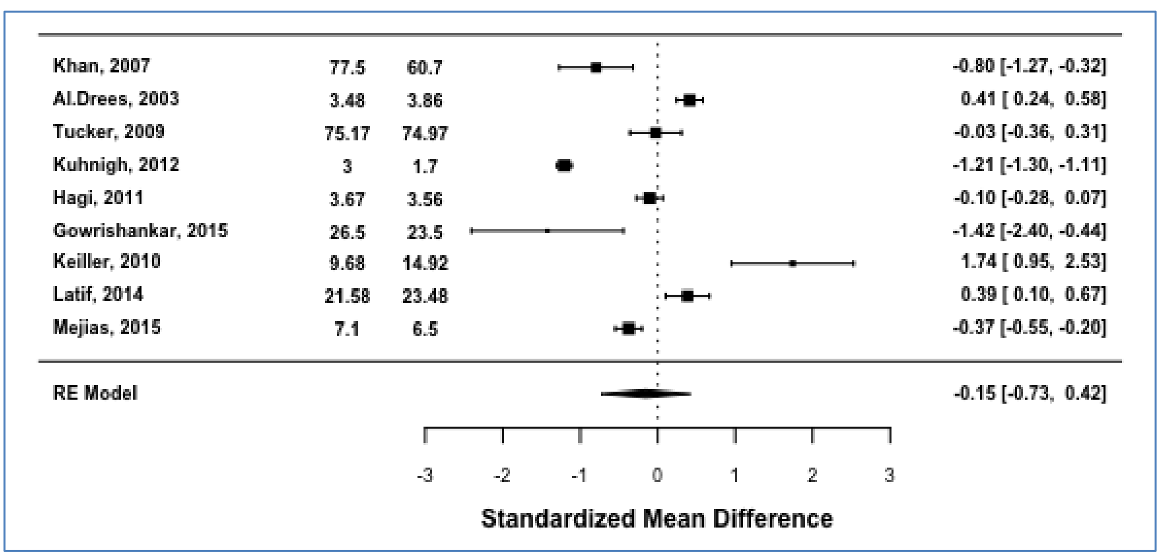


Figure 1. Attitude Forest Plot (Note: Column 1 = Author(s) and Year: Column 2 = Experimental Mean; Column 3 = Control Mean; Column 4 = Relative Risk; Column 5 = Confidence Interval).

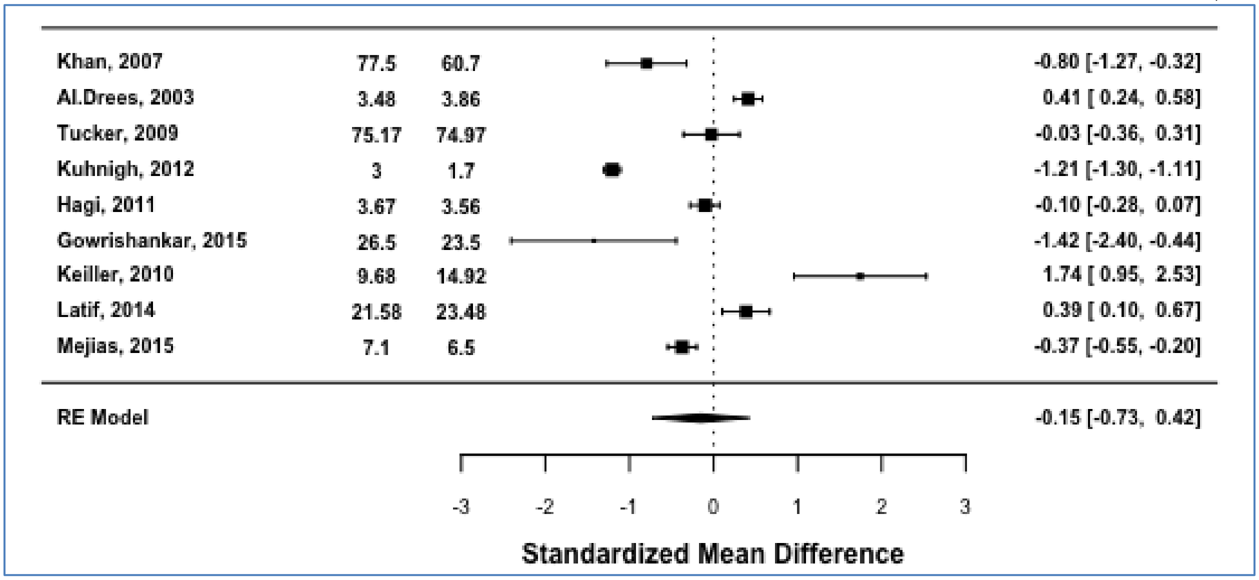


Figure 2. Knowledge Forest Plot. (Note: Column 1 = Author(s) and Year; Column 2 = Experimental Mean; Column 3 = Control Mean; Column 4 = Relative Risk; Column 5 = Confidence Interval).

Research question 1: To what extent have medical students' attitudinal behavior been impacted by the use of problem-based learning in medical environments? Figure 1 displays the effect sizes for attitudinal outcomes in regards to PBL. The strength on the left side of the table favors the experimental group. The experimental group PBL mean was 24.5 in comparison to that of the control group (TDL) which was 23.6. The attitudinal effect sizes represented in this data ranged from 0.03 to 1.74 (see Table 2). The results indicate that values below 0 have lower performance for the control group than that of the experimental group with the exception of three studies (3, 9, and 13 discussed below). The results indicate no statistical significance.

Impact of problem-based learning on attitudinal behavior.

Study three. Khan et al. (2007) did a comparison of knowledge and attitudes among two groups of undergraduate medical students involved in PBL (66) versus conventional lecture bases learning (84) LBL. The students were given a structured, validated questionnaire, which was tracked on a scale and compared for statistical significance. The PBL group scored 54% while the LBL students scored 55%. On the knowledge scale (p-value; 0.63), on the attitudes, PBL students scored 75.5% against 66.7% score on LBL students (p-value 0.021). Overall findings found that PBL students showed slightly healthier attitudes toward research compared to LBL students. However, both exhibited similar levels of knowledge, which supports the findings in this meta-analysis. Students exposed to PBL have better attitudes towards learning but tend not to exhibit great gains in knowledge over students exposed to LBL.

Study ten. Medical students' satisfaction and academic performance with problem-based learning in practice-based exercises for epidemiology and health demographics (Potturi, Singhchaudary, Agarwal, & Rastogi, 2015) aimed to evaluate the effect of PBL on students' satisfaction with performance in a health course. The participants in this interventional study were students enrolled in the Epi and Health course offered during the third year of the six-year degree program in medicine at the University of Granada during the 2010-2011 and 2011-2012 academic years. An anonymous survey was utilized to measure student satisfaction between the two teaching strategies. The questionnaire items were chosen from the Teaching Evaluation Questionnaire for Student Participation, which is a validated instrument for university-level students in Spain.

In the distribution of response categories on the satisfaction questionnaire in the two groups. The magnitude of positive responses for all items was higher for the PBL group, the PBL group also identified greater motivation and group work as the positive aspects mentioned most frequently. The results yielded an overall questionnaire score (maximum possible score of 16) of 10.6 which was significantly higher in the PBL group than in the TLG (9.4, $p < 0.001$). The greatest difference between groups was magnified in the area of perceived knowledge, the mean exam score was significantly higher in the PBL group (7.1, standard deviation = 1.6) than in the TLG (6.5, standard deviation = 1.6, $p<0.001$).

The study confirmed an association between the use of active techniques like PBL and greater student satisfaction, and maybe the most useful aspect of the study is the finding that PBL not only impacted student satisfaction, but that their boosted satisfaction rendered as advancement in academic performance. Overall the results strongly suggest a relationship that can be summarized as PBL leads to increased satisfaction, and increased academic performance.

Limitations of the study included, the methodology, sessions were offered to small groups of students at different times and were repeated weekly, this could have led to validity issues as the conditions were not exactly the same (Mejias et al., 2015).

Study nine. In another study, Potturi, Singh, Agarwal and Rastogi (2016) also found that PBL was a more effective technique for learning. The study was conducted on first year medical school students, over a period of 4 weeks. A total of 40 students participated in completing the Likert Scale questionnaire. Group A was significantly different from group B -Likert scale scores. Group A scores equaled 26.2 (S.D = 2.24) and Group B equaled 23.05 (SD =1.77) with t value 4.792, and p value 0.000013, with $p<0.05$, i.e. 95% of significance. Lastly, an independent-t test was used to add the significance difference in Likert Scale between Group A and Group B, outcomes of the study were evaluated by a feedback questionnaire. The questionnaire only contained 10 items and had a small population therefore this could have impacted overall findings.

Study thirteen. In contrast to findings from both studies above, Lucieer et al. (2016) did a comparison of a lecture-based curriculum and a problem-based curriculum on self-regulated learning. The quasi-experimental cross-sectional study was conducted across two medical schools one in Brazil and one in Belo Horizonte. The first medical school was lecture-based and the second school was one where the PBL approach had been implemented for nine years. 384 students completed the questionnaire, giving an overall response rate of 80.3%. In PBL the response rate was 85.7% (66/77) and the response rate in the LBC was 70.7% (111/157). The mean age of all respondents was 22.4 years. The data was analyzed with IBM SPSS AMOS 20 and IBM Statistics SPSS 20.

It was hypothesized that students in a PBL curriculum would show stronger development in learning skills, given that the skills were more explicitly incorporated in a PBL curriculum. The hypothesis was not supported therefore, the students in PBL did not show stronger development in learning skills however, this could have been attributed to weaknesses in implementation and the quality of learning material. Mounting research suggests that the backbone of PBL curriculums is implementation (Cebeci et al., 2013; Hartling et al., 2010). Limitations of this study included the cross-sectional design that was utilized, it was suggested that a longitudinal design might have been more informative; and some students completed the questionnaire on paper while others completed the questionnaire online.

Research Question 2: To what extent have medical students' academic outcomes been impacted by the use of Problem-based Learning (PBL) in medical environments?

Figure 2 displays the effect sizes for knowledge outcomes in regards to PBL. The strength on the left side of the table favors the experimental group. The experimental group PBL mean was 24.5 in comparison to that of the control group (TDL) which was 23.6. The knowledge effect sizes represented in this data ranged from 0.04 to 1.83. The results indicate that values below 0 have lower performance for the control group than that of the experimental group with the exception of two studies (study 13 discussed above) and study 2 (discussed below).The results indicate that no statistical significance.

Impact of problem-based learning on academic outcomes.

Study two. Al-Drees et al. (2015) concluded that most students reported that PBL sessions encouraged self-directed learning, and improved decision making skills. 275 (53.9%) of students completed the questionnaire, 60.7% were first-year medical students, 39.3% were second-year medical students, 24% were male and 76% were female. The students overall responses showed they were in agreement that PBL was beneficial in their learning process in a system-based hybrid curriculum (mean: 3.84 0.90). Male students (84.8%) and female students 75.6% also agree that PBL sessions were helpful also in understanding basic science concepts. On the other hand 54.5% of students reported a lack of proper training before starting PBL sessions and only 25.1% of students agreed that the teaching staff were well prepared to run the sessions; 76.7% of the students used lecture notes as a learning resource due to replication of topics between PBL sessions and lectures (p=0.07).

Significant negative effect sizes have been associated with the implementation of PBL when poorly trained facilitators and tutors are utilized. Which has also been reported to have a correlation with the universally accepted definition and structure of PBL (Prince, 2004).

Question 3: Does Problem-based Learning (PBL) have a greater impact on medical students' attitudinal behavior or academic outcomes? Figures 1 and 2 show which studies favor the experimental group mean over the control group mean. The strong experimental mean distribution to the left side of the plot indicates favor of the experimental group as a result both attitudinal behavior and academic outcome p-values are > 0.05, thus indicating no statistical significance. (see Table 3)

Study fourteen. Numerous studies highlighting students' performance has been conducted in the United States, Europe, and Australia (Keller, 2010; Tuker, Schlageter, Park, Rosenberg, Benjamin, & Nawar, 2009; Walker & Leary, 2009). A quantitative study on the Impact of case-based lectures on students' performance conducted by Larif (2014) assessed two groups of students (1) the lecture-based teaching group n=54, and (2) the case-based teaching group n=48. The evaluation on academic performance was measured by a written exam immediately following course completion, each exam was a 1-hr. multiple choice exam, and short-essay questions that assessed three levels of Bloom's taxonomy knowledge and structure. SPSS (version 13) software was used for statistical analysis. Descriptive statistics (such as means and SE) were compared between traditional and case-based student exam data. An unpaired t-test was used to analyze the exam data….. Statistical significance was set at the 95% confidence level ($p<0.05$).

Student performance was evaluated by comparing exam scores between the two classes. The study sought to investigate the differences in student performance between classes. The findings of this study affirm the findings of multiple studies in the literature documenting medical students' improved knowledge (immediately following course completion) with the use of case-based teaching. LBT group (106) = mean 21.58; SD 4.490.44<0.05, CBT group (92) =mean 23.48; SD 5.330.56. Student performance 2 months after course completion also improved LBT (58) = 7.98; SD 2.360.31<0.05, CBT (69) = 9.42; SD 3.240.39. Participants involved in this study were from one medical school therefore this could have generalized the findings. Therefore the validity of this study could be improved by sampling multiple populations across multiple medical schools.

Table 3

Random Effect Model and Heterogeneity

	Random-Effect Model					Heterogeneity		
	Estimate	se	z	*p*	CI	I^2 (%)	H^2	τ^2
Attitude	-0.15	0.29	0.52	-0.6030	(-0.72, 0.42)	98.38	61.63	0.72
Knowledge	-0.39	0.23	-1.65	0.0988	(-0.83, 0.07)	96.89	32.17	0.44

Note: SE = standard error; z = test-statistic; p = p-value; CI = confidence interval

Table 3 displays the random-effect model and heterogeneity, which suggests that the experimental group is not different from the control group for attitude and knowledge in the medical classroom since the p-value is > 0.05. The heterogeneity suggests difference in the effect size estimates. The amount of heterogeneity in the true effect for attitude is estimated $\hat{\tau}^2 = 0.73$ and knowledge is estimated $\hat{\tau}^2 = 0.44$. The attitude $I^2 = 98.38\%$ and knowledge $I^2 = 96.89\%$ is the amount of variability in the effect size. The attitude $H^2 = 61.63$ and knowledge $H^2 = 32.17$ represents the observed amount of sampling variability. "It is important to realize, however, that $\hat{\tau}^2$, I^2, and H^2 are often estimated imprecisely, especially when the number of studies is small" (Viechtbauer, 2010, p.14).

Study one. The results of this study are consistent with research throughout this meta-analysis. Nanda and Manjunatha (2013) investigated first-year medical students' perspectives of PBL learning experiences. Students participated in a systematically conducted PBL session in physiology after being exposed to 4 months of being taught traditionally. At the end of the experience students were asked to compare and rate their experiences with (1), traditional much better (2), traditional better (3), both the same (4), PBL better (5) PBL much better. Univariate analysis was performed and the scores were compared using two-sample t-test, the first analysis yielded results that were parallel among both groups therefore the study was repeated. For the second analysis responses were coded as follows: (2), traditional much better (1), traditional better (0) both the same (1) PBL better (2) PBL much better, for each response on the questionnaire the mean values for the responses favoring the traditional group were compared with mean values for responses favoring PBL group using unpaired tow-sample t-test. The difference between the means was calculated and significance was determined.

Of the 773 students recruited for the study, 159 students were among those in favor of traditional (Category “A”) and 614 students favored PBL (Category “I”). Overall mean scores for “A” was 0.79 mean scores for “I” was 0.00 p-value of 0.006. Overall findings noted the majority of students perceived that acquisition of knowledge and information gathering in physiology was better with PBL than with traditional teaching.

The level of acquired knowledge was not directly tested which was a major limitation of this study, the study only addressed student perceptions. Other limitations of the study included-reliability of the instrument used, which resulted in a null hypothesis in the first analysis and warranted a second analysis.

Summarization of Studies

The representation of studies included in this meta-analysis yielded results consistent with much of the current research surrounding PBL. Of the fourteen studies analyzed for this meta-analysis eight of the studies used questionnaires and six of the studies used exam scores and quiz scores as a means to investigate students’ attitudes, perceptions, knowledge and academic outcomes. Favorable results supporting PBL were highlighted across twelve of the fourteen studies. However, findings from two of the studies yielded no significant differences between the outcomes of the independent studies when students were exposed to traditional teaching methods versus PBL.

A common theme among the studies were limitations that involved the methodology. It was suggested in many of the studies that longitudinal designs may have been better than a cross-sectional design which most were. Other limitations included: generalizations due to studies being limited to single medical schools, variations in the way different groups were administered the questionnaire, and differences in definitions and implementations of PBL across institutions. Also noted were differences in the comparisons of groups regarding attitudes of students who were first-year, second-year, third-year, and fourth-year students, it appeared that the longer students were exposed to PBL curriculums the more favorable their assessments were of the strategy, maybe because they were at the higher-level that Bloom, 1956 discussed.

Publication Bias

A variation among studies used in a meta-analysis can resemble publican bias therefore, due to contradictory data about whether publication bias exists and to what extent, it was assessed in this meta-analysis. Funnel plots were used as a visual method of assessing publication bias. In a funnel plot, studies are organized by effect size on the x-axis and standard error on the y-axis (Russo, 2007). As a result, studies with larger sample sizes band at the Figure the graph with a smaller dispersion left to right, with smaller sample sizes spread across the bottom of the graph with a wider dispersion left to right. Publication bias is indicated by a slope of studies in the direction of the right side (higher effect size) of the funnel plot (see Figure 3. Figures 3 and 4 are attitudinal and knowledge funnel plots. These plots indicate there is no publication bias. Neither Egger's regression test for attitude and knowledge ($p = 0.8250$ / .3876) nor the Rank correlation test ($p = 0.7614$/ .3585) was statistically significant so there's no evidence of publication bias according to these tests both published and unpublished studies were included to address potential publication bias, though they were coded appropriately for further analysis to determine differences; likewise, both peer-reviewed and non-peer-reviewed studies were included and coded. Studies which included at least one category (study rubric) was included. For example, Potturi, Singhchaudary, Agarwal & Rastogi, (2016).

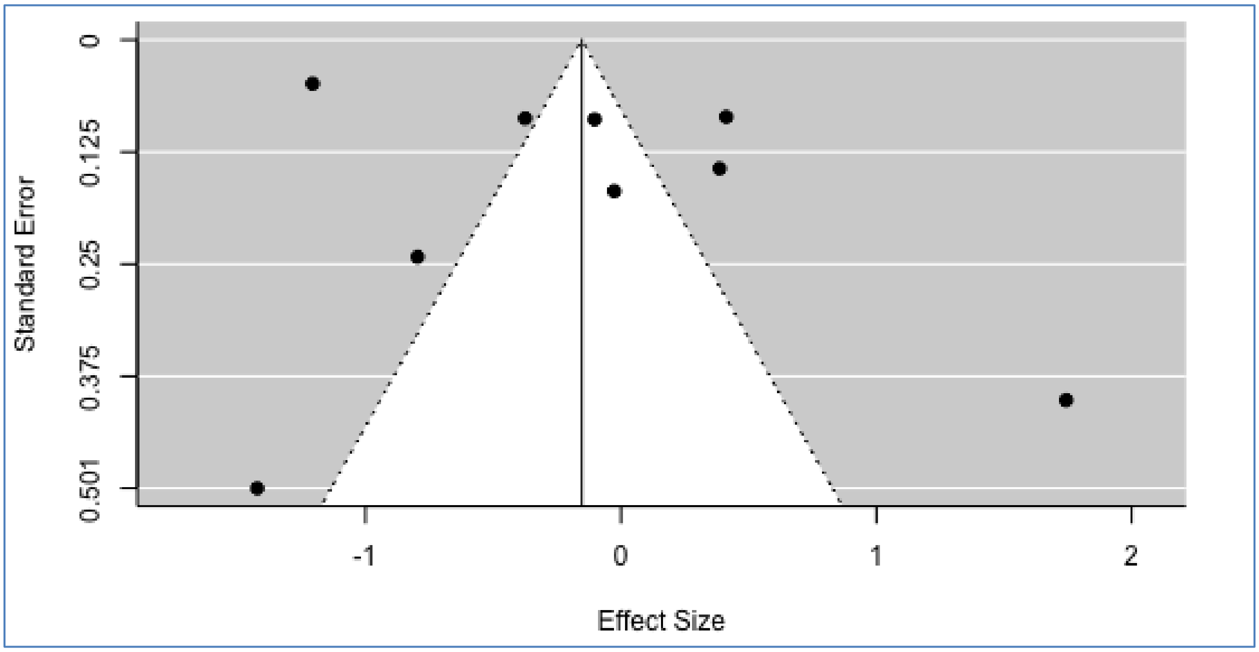


Figure 3. Attitude Funnel Plot

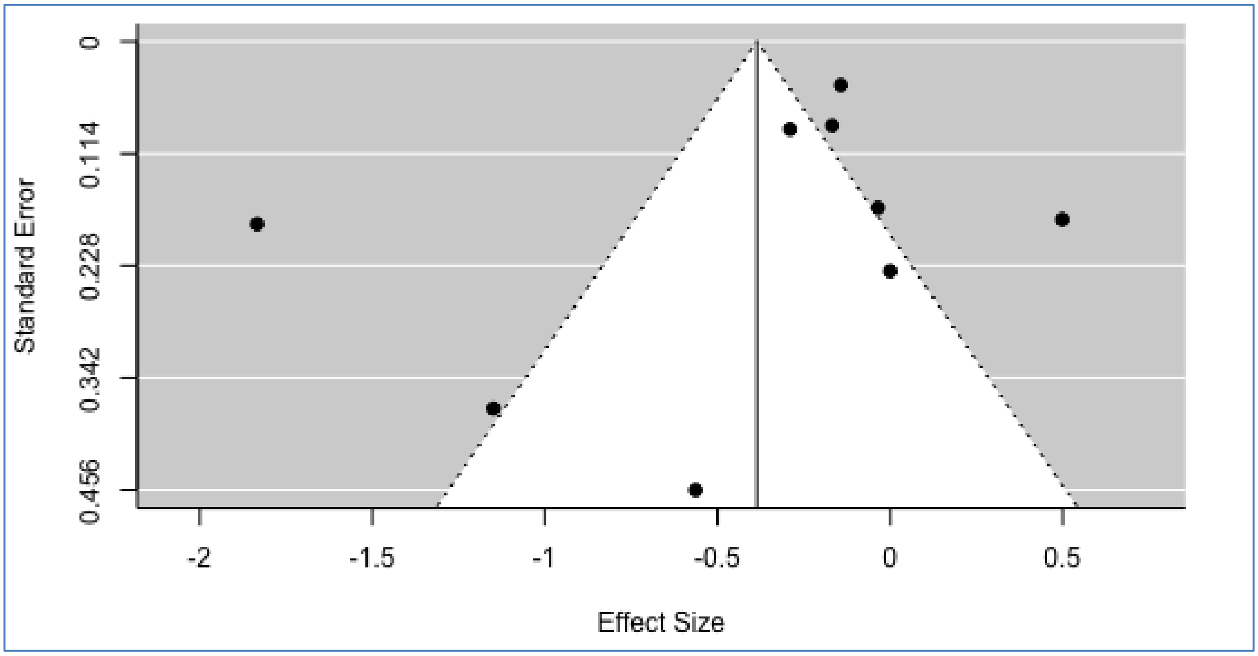


Figure 4. Knowledge Funnel Plot

Summary

The results section reported results for each research question. Descriptive statistics, samples and effect size means were reported. Tables were used to summarize and illustrate the findings. The purpose of this study was to examine the impact of Problem-based Learning on medical students' attitudinal behavior and academic outcomes. This chapter discussed the results of the analyses conducted in this study. Data entry and analysis was carried out utilizing Statistical Package R: A Language and Environment for Statistical Computing (R Core Team, 2016). This software was used to measure the impact of PBL on medical students' attitudes and academic outcomes. The quantitative data were presented in the form of means and standard deviations. Chapter 5 will provide a detailed summary and discussion of the findings and their implications.

Chapter V: Limitations, Recommendations, Implications, and Summary

The data for this study was obtained from an analyses of fourteen independent research studies. This study utilized a statistical meta-analytic technique to make connections among the studies and to synthesize findings across multiple primary studies for the purpose of systematically investigating the effect of medical student exposure to PBL. A review of the literature returned a concentration of empirical research studies in the areas of PBL, medical students' attitudinal behavior and medical students' academic outcomes, osteopathic and allopathic student outcomes. Characteristics of the primary studies were studied for the purpose of determining affiliation between students' use of PBL and their attitudinal and academic outcomes. The experimental mean was 25.29 and the control mean was 23.68

Purpose of the Study

The purpose of this study was to review existing research literature on the effect of Problem-based Learning on medical students' attitudinal behavior and academic outcomes. Answers to these questions will provide a better understanding of how medical students' attitudinal behavior and academic outcomes have been impacted by the use of Problem-based Learning beyond course performance. Medical students' attitudinal behavior towards PBL curriculums have been the focus of several studies, however the studies have yielded conflicting findings in research literature. Therefore it is necessary to connect and further investigate opposing findings by investigating independent studies that have reported effects of PBL on medical students' attitudinal behavior, and academic outcomes. Fourteen studies met criteria for inclusion and are included in this investigation. This research builds upon and adds to the existing literature regarding Problem-based Learning and medical students' outcomes. This research also serves as a resource for medical educators, deans, associate deans and stakeholders as it will provide a more in-depth understanding of how pedagogical practices impact medical students' academic outcomes as a means to alter the instructional practices that are predominate in the medical environments.

Research Questions

The study examined the following questions:

1. To what extent have medical students' attitudinal behavior been impacted by the use of Problem-based Learning (PBL) in medical environments?
2. To what extent have medical students' academic outcomes been impacted by the use of Problem-based Learning (PBL) in medical environments?
3. Does Problem-based Learning (PBL) have a greater impact on medical students' attitudinal behavior or medical students' academic outcomes?

Limitations of the Study

The limitations of this research should be considered by the reader throughout the review of this study**.** This study utilized independent studies to conduct a meta-analysis. Weaknesses related to meta-analysis in general include publication bias and lack of methodological quality of independent primary studies. Therefore the conclusions of this meta-analysis rely heavily on the studies identified to estimate pooled effects.

Regarding the studies analyzed to support research questions one and two, the instruments measuring quantitative results among the studies varied by author. Although, the majority (7) of studies utilized questionnaires as a means to measure attitude and knowledge. The variations among instruments could have impacted effect sizes across studies, therefore the employment of a standardized instrument may impact overall effect sizes.

Recommendations for Future Research

Problem-based Learning had a significant impact on medical students' attitudes and academic outcomes in comparison to that of the traditional didactic lecture. Future research should examine the varied universally accepted definitions of Problem-based Learning, and the quality of the current theoretical model. Future research should also examine the impact of PBL on learning styles and the impact of PBL on class attendance. *In A delicate balance: Integrating active learning into a large lecture course* (Walker, Cotner, Baepler & Decker, 2008) the overall attendance in a large introductory science course was investigated and turned out to be significantly higher in the active session than in the traditional section (.968 vs. 0.927, $p< 0.01$). Although not included in this meta-analysis some research implies that attendance in lecture based curriculums is lower than attendance in PBL curriculums (Hmelo-Silver, 2004; Walker, Cotner, Baepler & Decker, 2008).

Implications for Practice

According to Cebeci et al. (2013) learning approaches and study skills of medical students in medical schools are very extensive, warranting an investigation into ways to support their learning. Since, it is known that students' approaches to learning are exaggerated by the effectiveness and quality of pedagogical practices implemented in the classroom. "Future physicians must learn how to learn and how to eliminate and integrate relevant information to diagnose and work out their patients' problems in the best possible way" (Cebeci, p. 732). Therefore, in order to address this researchers suggest active learning as a means to make the nature of education greater and the quality of upcoming physician's treatment better in regards to patient care.

Problem-based Learning curriculums and pedagogical practices of exemplary medical institutions should be examined and serve as a model for medical institutions who seek to implement quality PBL curriculums. The strength of Problem-based Learning curriculums rests in the quality of the faculty facilitators. Therefore, it would also be beneficial to examine stellar professional development models.

The information provided in this study is beneficial because it adds to the current research literature on the effectiveness of Problem-based Learning as an effective pedagogical practice. The present educational restructure is moving away from passive pedagogies towards more active pedagogies that have been proven to work (Bonwell & Eison 1991; Cook-Sather, 2011) like PBL (Borrows, 1986). Therefore programs outside of medical institutions, such as STEM programs in K-12 and higher education institutions should further examine PBL curriculums and its impact on high school and college students' attitudinal and academic outcomes. As it is important for all educational institutions to evaluate their current pedagogical practices, and strive to implement changes in curricula that will lead to improved student outcomes, and a possible increase in class attendance, which in many higher education classrooms is an ongoing problem.

Summary

This study examined the impact of PBL on medical students' attitudinal and academic outcomes. Relationally, medical students' attitudinal behavior and medical students' academic outcomes were impacted equally indicating that PBL has an equal impact on students' attitudes and academic outcomes. However, PBL had no statistical impact on medical students' attitudinal behavior and academic outcomes. This research lends to the current research on active learning, and Problem-based Learning as a technique.

References

Al-Drees, A., Khalil, M. & Irshad M. (2015). Students' perception towards the problem-based learning tutorial session in a system-based hybrid curriculum. *Saudi Med J*, *36*(3), 341-348.

Allen, D. & Tanner, K. (2005). Infusing active learning into the large-enrollment biology class: Seven strategies, from the simple to complex. *Cell Biology Education, 4*, 262–268.

Armbruster, P., Patel, M., Johnson, E., & Weiss, M. (2009). Active learning and student-centered pedagogy improve student attitudes and performance in Introductory Biology. *CBE Life Science Education, 8,* 203–213.

Baker, H., Foster, R., Bates, B., Cope, M., McWilliams, T., & Musser, A. (2000). Relationship between academic achievement and comlex-usa level 1 performance: A multisite study. *JAOA*, *100*(4).

Barr, R. D., & Parrett, W. H. (2003). Saving our students, saving our schools: 50 proven strategies for revitalizing at risk students and low performing schools. Glenview, IL: Skylight Professional Development.

Balasubramaniam, G., & Indhu, K. (2016). A study of learning style preferences among first year undergraduate medical students using vark model. *Education in Medicine Journal*, *8*(4).

Bers, T., Chun, M., Daly, W. T., Harrington, C., & Tobolowsky, B. F. (2015). Foundations for critical thinking. *National Resource Center for the First-Year Experience and Students in Transition*. Available at: http://www.nrcpubs.com/p/125/foundations-for-critical-thinking.

Bhagat, A., Vyas R., & Singh, T. (2015). Students awareness of learning styles and their perceptions to a mixed method approach of learning. *Int. App Basic Med Res, 5,* S58-65.

Bloom, B. (1956). Bloom taxonomy of educational objectives: Book 1. New York: Longmans Green.

Bonwell, C. & Eison, J. A. (1991). Active learning: Creating excitement in the classroom. *ASHE-ERIC Higher Education Reports, 1*, Washington, DC: George Washington University.

Borenstein, M., Hedges, L., Higgins, J., & Rothstein, H. (2009). Introduction to meta-analysis. *Wiley Online Library.* Retrieved from http://onlinelibrary.wiley.com.

Borrows, H. S. (1986). A taxonomy for problem-based learning methods. *Medical Education, 20,* 481-486.

Bransford, J. D., Brown A. L., & Cocking R. R. (2000). *How People Learn: Brain, Mind, Experience, and School. Committee on Developments in the Science of Learning.* Washington, DC: National Academies Press.

Brawer, J., Lener, M., & Chalk, C. (2015). Student perceptions on the value of lectures. *Medical Science Education, 19*, 84-88.

Brookfield, S. (2006). *The Skillful teacher: On technique, trust, and responsiveness in the classroom* (2^{nd} ed.) San Francisco, CA: Jossey-Bass.

Carnegie Foundation for the Advancement of Teaching**.** (2006). Carnegie Classification of Institutions of Higher Education (online). http://www.carnegiefoundation.org/ classification [9 June 2006].

Casassus, P., Hivon, R., Gagnayre, R., d'Ivernois, J. F. (1999). An initial experiment in haematology instruction using the problem-based learning method in third-year medical training in France. *Hematol Cell Ther, 41*(4), 137-144

Cavanagh, M. (2011). Students' experiences of active engagement through learning activities in lectures. *Active Learning in Higher Education, 12,* 23-33.

Cebeci, S., Dane, S., Kaya, M., & Yigitoglu R. (2013). Medical students' approach to learning and study skills. *Procedia-Social and Behavioral Sciences, 93*, 732-736.

Chick, N. L., Haynie, A., & Gurung, R. A. R. (Eds.) (2012). *Exploring more signature pedagogies: Approaches to teaching disciplinary habits of mind*. Sterling, VA: Stylus.

Chickering, A. & Gamson, Z. (1987). Seven principles for good practice in undergraduate education. *AAHE Bulletin 39*, 3-7.

Christman, E. (1995). *A meta-analysis of the effect of computer-assisted instruction on the academic achievement of students in grades 6 through 12: A comparison of urban, suburban, and rural educational settings*. (Unpublished Doctoral Dissertation). Old Dominion University, Norfolk, VA.

Cook, E.D. & Hazelwood, A.C. (2002). An active learning strategy for the classroom- "Who wants to win… some mini chips ahoy?" *Journal of Accounting Education, 20*(4), 297.

Cooke, M., Irby, D., & O'Brien, B. (2010). A call for reform of medical school and residency. *Educating Physicians*, Retrieved from http://samples.sainsburysebooks.co.uk/ 9780470617632_sample_389799.pdf.

Cook-Sather, A. (2011). Lessons in higher education: Five pedagogical practices that promote active learning for faculty and students. *Journal of Faculty Development*, *25*(3), 33-39.

Cuthbert, P. (2005). The student learning process: Learning styles or learning approaches? *Teaching in Higher Education, 10*(2), 235-249.

Davis, T. A., (2013). Connecting students to content: Student-generated Questions. Bioscene: *Journal of College Biology Teaching*, *39*(2), 32-34.

DeCoster, J. (2004). Meta-analysis notes. Retrieved from: www.stat-help.com/notes

Demirel, M. & Dagyar, M. (2016). Effects of problem-based learning on attitude: a meta-analysis study. *Eurasia Journal of Mathematics, Science & Technology Education, 12*(8), 2115-2137.

Dietz, J. R. & Stevenson, F. T. (2011). Active learning in a large medical classroom setting for teaching renal physiology. *Advances in Physiology Education*, *35*(4), 456-45. http://dx.doi.org/10.1152/advan.00081.2011.

Dochy, F., Segers, M., Bossche, V., & Gijbels, D., (2003). Effects of problem-based learning: a meta-analysis. *Learning and Instruction, 13*, 533-568.

Donner, R. S. & Bickley, H. (1993). Problem-based learning in American medical education: an overview. *Bulletin of the Medical Library Association*, *81*(3), 294–298.

Doyle, T. (2008). *Helping Students learn in a learner-centered environment: A guide to facilitating learning in higher education.* Sterling, VA: Stylus Pub.

Drowns, R. L. & Rudner, R. (1991). Meta-analysis in educational research. *Practical assessment, research & evaluation, 2*(8). Retrieved January 19, 2017 from http://edresearch.org/pare/getvn.asp?

Duffy, T. P. (2011). The Flexner Report – 100 Years Later. *Yale Journal of Biology and Medicine 84*(3), 269-276.

Ebert-May D., Brewer C., & Sylvester A. (1997). Innovation in large lectures teaching for active learning. *Bioscience. 47*, 601–607.

Ellis, P. (2010). Understanding research for nursing students. Sage Publications.

Emerald, N., Aung, P., Han, T., Yee, K., Myint, M., Soe, T., & San, O S. (2013). Students' Perceptions of problem-based learning conducted in phase 1 medical program, UCSI University, Malaysia. *South East Asian Journal of Medical Education, 7*(2).

Feeley, A., (2015). Exam success at undergraduate and graduate-entry medical schools: Is learning style or learning approach more important? A critical review exploring links between academic success, learning styles, and learning approaches among school-leaver entry ("traditional") and graduate-entry ("nontraditional") medical students. *Teaching and Learning in Medicine*, 27(3) 237-244.

Fink, L. D. (2003). Creating significant learning experiences. San Francisco, Jossey-Bass.

Frederick, P. (1986). The lively lecture – 8 Variations. *College Teaching, 34,* 43-50.

Freeman, S., Eddy, S., McDonough, M., Smith, M., Okoroafor, N., Jordt, H. & Wenderoth, M. (2013). Active learning increases student performance in science, engineering and mathematics. *PNAS*, *111*(23), 8410-8415.

Gadt-Johnson, C. & Price, G. (2000). Comparing students with high and low preferences for tactile learning. *Education*, *120*(3), 581-585.

Garcia, P., Ginsburg, D., & Voth, J. (2017). Problem-based learning. Department of Medical Education, Northwestern University. http://www.feinberg.northwestern.edu

Gardner, H. (1985). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.

Glass, G. V. (1976). Primary, secondary, and meta-analysis. *Educational Researcher, 5*, 3-8.

Glass, G.V, McGaw, B., & Smith, M. L. (1981). *Meta-analysis in social research.* Beverly Hills, CA: Sage Publications.

Graffam, B., (2007). Active Learning in Medical Education: Strategies for Beginning Implementation. *Medical Teacher, 29*(1).

Gregory, J. L. (2013). Lecture is not a dirty word: How to use active lecture to increase student engagement. *International Journal of Higher Education*, 2(4), 116-122.

Griggs, S. (1985). Counseling for individual learning styles. *Journal of Counseling and Development*, *64*(3), 202-205.

Gurung, R. A. R., Chick, N. L., & Haynie, A. (Eds.) (2009). *Exploring signature pedagogies: Approaches to teaching disciplinary habits of mind.* Sterling, VA: Stylus.

Hackathorn, J., Solomon, E., Blankmeyer, K., Tennial, R., & Garczynski, A., (2011). Learning by doing: An empirical study of active teaching techniques. *The Journal of Effective Teaching, 11*(2), 40-54.

Haidet, P., Morgan, R., O'Malley, K., Morgan, K., Moran, B., & Richards, B. (2004). A controlled trial of active versus passive learning strategies in a large group setting. *Adv. Health Science Education Theory Practice 9(*1), 15-27.

Hagi, S., & Al-Shawwa, L., (2011). Evaluation of second and fourth year undergraduate medical students' perception and acceptance of the problem-based learning process. *Saudi Medical Journal, 32*(10): 1060-1065.

Hartling, L., Spooner, C., Josvold, L., & Oswald, A. (2010). Problem-based learning in pre-clinical medical education: 22 years of outcome research. *Medical Teacher,* 32, 28-35.

Hmelo-Silver, C. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235-266

Higgins, J., Lane, P., Anagnostelis, B., Anzures-Cabrera, J., Baker, N., Cappelleri, J., Haughie, S., Hollis, S., Lewis, S. C., Moneuse, P. & Whitehead, A. (2013). A tool to assess the quality of a meta-analysis. *Research Synthesis Methods, 4*(4), 351-366

Hinduja, K., Samuel, R., Mitchell, S. (2005). Problem-based learning: Is anatomy a casualty? *PubMed, 3*(2), 84-87

Huber, M. T. & Morreale, S. P. (2002). *Disciplinary styles in the scholarship of teaching and learning: Exploring common ground.* Washington DC: American Association for Higher Education and The Carnegie Foundation for the Advancement of Teaching.

James, W. & Maher, P. (2004). Understanding and using learning styles. In Michael W. Galbraith (Ed). *Adult Learning Methods: A guide for effective Instruction,* 3rd ed. (pp. 23-37). Malabar, Florida: Krieger Publishing Company.

Jones, R. W. (2006). Problem-based learning: description, advantages, disadvantages, scenarios and facilitation. *Australian Society of Anesthetists, 34*(4).

John Hopkins University, http://www.hopkinsmedicine.org/som/

Kelson, A., & Distlehorst, L. (2000). Groups in problem-based learning (PBL): Essential elements in theory and practice. Problem-based learning: *A research perspective on learning interactions*, 167-184.

Khan, H., Taqui, A., Rizwanulhaq, M., & Fatmi, Z., (2007). Problem-based versus conventional curricula: influence on knowledge and attitudes of medical students towards health research. *Plos ONE* 2(7) e632.

Kimmel, P. (1992). Abandoning the lecture: curriculum reform in the introduction to clinical medicine. *The Pharos, 55,* 36-38.

Knight, J. K. & Wood, W. B. (2005). Teaching more by lecturing less. *Cell Biol. Education, 4*, 298–310.

Kolb, D. (1984). *Experiential learning: Experience as the source of learning and development.* New York: Prentice-Hall.

Komarraju, M. & Karau, S., (2008). Relationship between the Perceived Value of Instructional Techniques and Academic Motivation. *Journal of Instructional Psychology, 35*, 70-82.

Koper, R. (2006). Current research in learning design. *Educational Technology & Society*, *9*(1) 13-22.

Latif, R. (2014). Impact of case-based lectures on students' performance in vascular physiology module. *Advanced Physiology Education*, *38*(3), 268-272.

Lenz, P., McCallister, J., Luks, A., Le, T., & Fessler, H. (2015). Practical strategies for effective lectures. *Annals of The American Thoracic Society, 12*(4), 561-566.

Lipsey, M. & Wilson, D., (2001). The role of method in treatment effectiveness research: Evidence from meta-analysis. *Psychological Methods*, 6(4), 413-429.

Lucieer, S., Vandergeest, J. N., Eloi-Santos, S. M., Delbone de Faria, R. M., Jonker, L., Visscher, C., Rikers, R., Themmen, A. (2016). The development of self-regulated learning during the pre-clinical stage of medical school: a comparison between a lecture-based and a problem-based curriculum. *Advances in Health Science Education, 21*, 93-104.

Lujan, H.L. & DiCarlo, S.E., (2006). Too much teaching, not enough learning: what is the solution? *Advanced Physiological Education, 30*, 17–22.

Lycke, K., Grottum, P., & Stromso, H. (2006). Student learning strategies, mental models and learning outcomes in problem-based and traditional curricula in medicine. *Medical Teacher, 28*(8), 717-722.

Machemer, P. & Crawford, P. (2007). Student Perceptions of active learning in a large cross-disciplinary classroom. *Active Learning in Higher Education. Sage Publications: London, Los Angeles, New Delhi and Singapore, 8*(1), 9-30.

Marbach-Ad, G., Seal, O., & Sokolove, P. (2001). Student attitudes and recommendations on active learning: a student-led survey gauging course effectiveness. *J. Coll. Sci. Teach. 30*, 434–438.

Martinez, I., Vega, I., Wells, A., Mora, J., & Gillis, M., (2015). Twelve tips for teaching social determinants of health in medicine. *Medical Teacher*, *37*, 647-652.

Mather, J. A. & Champagne, A. (2008). Student learning styles/strategies and professors' expectations: Do they match? *College Quarterly, 11*(2), 1-8.

Mazur, E. (2009). Farewell Lecture? *Science*, 323(5910), 50-51.

McKeachie, W. (1994). *Teaching Tips*. Lexington, MA: D.C. Heath and Co.

McLaughlin J., Roth, M., Glatt, D., Gharkholonarehe, N., Davidson C., Griffin, L., Esserman D., & Mumper, R. (2014). The flipped classroom: a course redesign to foster learning and engagement in a health professions school. *Academic Medicine, 89*(2), 236-243.

Mejias, E., Prieto, A., Ruiz, V., Porcel, M. C., Moleon, J., & Claret, L., (2015). Medical student's satisfaction and academic performance with problem-based learning in practice-based exercises for epidemiology and health demographics. *Innovations in Education and Teaching International*, *52*(5), 510-521.

Mennin, D. S., Heimberg, R. G., Turk, C. L., Fresco, D. M. (2002). Applying an emotion regulation framework to integrative approaches to generalized anxiety disorder. *Clinical Psychology: Science and Practice, 9*, 85-90

Messineo, M., Gaither, G., Bott, J., & Ritchey, K. (2007). Inexperienced versus experienced students' expectations for active learning in large classes. *College Teaching, 55*(3), 125-133.

Miller, C.J., & Metz, M.J. (2014). A comparison of professional-level faculty and student perceptions of active learn learning: its current use, effectiveness, and barriers. *Advance Physiology Education 38*, 246 –252.

Miller, C. J., McNear, J., & Metz, M. J. (2013) A Comparison of traditional and engaging lecture methods in a large, professional-level course. *Advances in Physiology Education, 37*(4), 347-355.

Nanda, B. & Manjunatha, S. (2013). Indian medical student's perspectives on problem-based learning experiences in the undergraduate curriculum: One size does not fit all. *Journal of Educational Evaluation for Health Professions, 10(*11).

National Research Council (NRC) (1999). *Transforming Undergraduate Education in Science, Mathematics, Engineering and Technology*. Washington, DC: National Academies Press.

Newble, D. & Cannon, R. (1994). *A Handbook for Medical Teachers*. Boston, MA: Kluwer Academic.

Pace, D., & Middendorf, J. (2004). Decoding the disciplines: Helping students learn disciplinary ways of thinking. San Francisco, CA: Jossey-Bass.

Petticrew, M. & Roberts, H. (2006). Frontmatter, in systematic reviews in the social sciences: A practical guide. Blackwell Publishing Ltd. Oxford, UK.

Penuel, W., Kim, D., Michalchik, V., Lewis, S., Means, B., Murphy, R., Korbak, C., Whaley, A., & Allen, J. (2002). Use of educational technology in home and school: A review of the knowledge base and case studies of best practice. SRI International, SRI Project 11060. Prepared for the planning and Evaluation Service, U. S. Department of Education DHHS Contract # 282-00-008-Task 1. Menlo Park, CA: SRI International.

Potturi G., Singhchaudary, K. B., Agarwal, A., & Rastogi, N. (2016). A comparative study on the efficacy of PBL problem based learning and ABL activity based learning in perceiving anatomy among physiotherapy students. *International Journal of Physiotherapy and Research, 4*(3), 1479-83.

Powell, N., Cleveland, R., Thompson, S., & Forde, T. (2012). Using multi-instructional teaching and technology supported active learning strategies to enhance student engagement. *Technology Integration in the Classroom, 4*(2).

Prince, M. J. (2004). Does active learning work? A Review of the research. *Journal of Engineering Education, 93*, 223–231.

Prober, CG, & Heath, C. (2012). Lecture halls without lectures—a proposal for medical education. *New England Journal of Medicine, 366,* 1657–1659.

R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Retrieved from https://www.R-project.org/

Richardson, D. (2007). Don't dump the didactic lecture; fix it. *Advanced Physiological Education*, *32*, 23–24.

Russell, A., Comello, R., & Wright, D. (2007). Teaching Strategies Promoting Active Learning in HealthCare Education. *Journal of Education and Human Development, 1*(1).

Russo, M. W. (2007). How to Review a Meta-analysis. *Gastroenterology & Hepatology, 3*(8), 637–642.

Saga, Z., Qamar, K., & Trali, G. (2015). Learning styles-understanding for learning strategies. *Pak Armed Forces Medical Journal*, *65*(5), 706-709.

Schmidt, F., Harter, J., Killham, E., Agrawal, S. (2009). Q12 meta-analysis: The relationship between engagement at work and organizational outcomes. Gallup, Inc.

Shukar, I., Zainab, R., & Rans, M. (2013). Learning styles of postgraduate and undergraduate medical students. *Journal of the College Physicians and Surgeons Pakistan*, *23*(1), 25-30.

Shulman, L. S., (2005). Signature Pedagogies in the professions. *Daedalus*, *134*(3), 52-59.

Silverthorn, D., Thorn, P., & Svinicki, M. (2006). It's difficult to change the way we teach: Lessons from the integrative themes in physiology curriculum model project. *Advances in Physiology Education*, *30*(4), 204-214.

Sivam, S. P., Latridis, P. G., Vaughn, S. (1995). Integration of pharmacology into a problem-based learning curriculum for medical students. *Medical Education*, *29*, 289-296

Slavin, R. E. (2000). *Educational Psychology: Theory and practice*. Boston, MA: Allyn & Bacon.

Smith, V. C. & Cardaciotto L. (2011). Is active learning like broccoli? Student perceptions of active learning in large lecture classes. *JoSoTL, 11*, 53-61.

Tangney, S. (2014). Student-Centered Learning: A Humanist Perspective. *Teaching In Higher Education*, *19*(3), 266-275.

Tuker, P., Schlageter M., Park E., Rosenberg E., Benjamin A., & Nawar, O., (2009). Medical student psychiatry examination performance at VA and non-VA clerkship sites. *Academic Psychiatry*, *33*(1), 23-26.

Tsang, A. & Harris, D., (2016). Faculty and second year medical student perceptions of active learning in an integrated curriculum. *Advances in Physiology Education, 40*(4), 446-453.

Van Amburgh, J. A., Devlin, J. W., Kirwin, J. L. & Qualters, D. M. (2007). A tool for measuring active learning in the classroom. American Journal of Pharmaceutical Education, 71(5), 85.

Viechtbauer, W. (2010). Hypothesis tests for population heterogeneity in meta-analysis. *British Journal of Mathematical and Statistical Psychology, 60*(1), 14.

Walker, J.D., Cotner, S. H., Baepler, P.M. & Decker, M. D. (2008). A delicate balance: Integrating active learning into a large lecture course. *CBE Life Sciences Education*, *7*(4), 361-367

Walker, A. & Leary, H. (2009). A problem based learning meta analysis: Differences across problem types, implementation types, disciplines, and assessment levels. *Interdisciplinary Journal of Problem-Based Learning,* 3(1).

Walker, A., Leary, H., Hmelo-Silver, C., & Ertmer, P. (2015). Essential readings in problem-based learning: exploring and extending the legacy of howard s. borrows. West Lafayette: Purdue University Press. Retrieved March 1, 2017, from Project MUSE database.

Wang J., Xu, Y., Liu, X., Xiong, W., Xie, J., & Zhao, J., (2016). Assessing the effectiveness of problem-based learning in physical diagnostics education in china: a meta-analysis. *Scientific Reports, 6,* 36279.

Warren, R. G. (1997). Engaging students in active learning. *About Campus*, *2*(1), 16-20.

Weimer, M. (2015). More evidence that active learning trumps lecturing. *Faculty Focus. Higher ED Teaching & Learning.* Retrieved From: http://www.facultyfocus.com/articles/teaching-professor-blog

White, C., Bradley, E., Martindale, J., Roy, P., Patel, K., Yoon, M., & Worden, M.K. (2014). Why are medical students ‘checking out’ of active learning in a new curriculum? *Medical Education 48*, 315–324.

Yilmaz, G. (2014). Let's peel the onion together: An application of Schein's model of organizational culture. *Communication Teacher*, *28*(4), 224-228.

Zahid M., Varghese R., Mohammed A., & Ayed A., (2016). Comparison of the problem-based learning-driven with the traditional didactic-lecture-based curricula. *International Journal of Medical Education. 7,* 181-187.

Appendix A

Engagement Search Terms by Database

Engagement Search Terms by Database

Database	Exact Terms and Phrases	Selections within Database
AUETD/Theses and Dissertation	PBL active learning, attitudes, education, student learning, student knowledge, attitudinal, medical student, medical education	active, medical school, osteopathic, allopathic
Education Research Complete	PBL active learning, attitudes, education, student learning, student knowledge, attitudinal, medical student, medical education	active, education, learning Osteopathic, allopathic, medical school curriculum, premed
ERIC (EBSCO)	PBL active learning, attitudes, education, student learning, student knowledge, attitudinal, medical student, medical education	active, education, allopathic, Osteopathic, medical school curriculum, premed
Google Scholar	PBL active learning, attitudes, education, student learning, student knowledge, attitudinal, medical student, medical education	active, education, allopathic, Osteopathic, medical school curriculum, premed
ProQuest	PBL active learning, attitudes, education, student learning, student knowledge, attitudinal, medical student, medical education	active, medical school, STEM, osteopathic, allopathic
PubMed	PBL active learning, attitudes, education, student learning, student knowledge, attitudinal, medical student, medical education	active, education, learning preference, Osteopathic, allopathic
Medline (Ebsco)	PBL active learning, attitudes, education, student learning, student knowledge, attitudinal, medical student, medical education	active, education, learning preference, Osteopathic, allopathic

Appendix B

Quality Assessment Tool for Quantitative Studies

QUALITY ASSESSMENT TOOL FOR QUANTITATIVE STUDIES

COMPONENT RATINGS

A) SELECTION BIAS

(Q1) Are the individuals selected to participate in the study likely to be representative of the target population?
Very likely
Somewhat likely
Not likely
Can't tell

(Q2) What percentage of selected individuals agreed to participate?
80 - 100% agreement
60 – 79% agreement
less than 60% agreement
Not applicable
Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK

B) STUDY DESIGN

Indicate the study design
Randomized controlled trial
Controlled clinical trial
Cohort analytic (two group pre + post)
Case-control
Cohort (one group pre + post (before and after))
Interrupted time series
Other specify ____________________________
Can't tell

Was the study described as randomized? If NO, go to Component C.

No Yes

If Yes, was the method of randomization described? (See dictionary)
No Yes

If Yes, was the method appropriate? (See dictionary)

No Yes

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

C) CONFOUNDERS

(Q1) Were there important differences between groups prior to the intervention?

Yes
No
Can't tell

The following are examples of confounders:
Race
Sex
class size
Age
class level
Educational Setting
Pre-intervention score on outcome measure

(Q2) If yes, indicate the percentage of relevant confounders that were controlled (either in the design (e.g. stratification, matching) or analysis)?
80 – 100% (most)
60 – 79% (some)
Less than 60% (few or none)
Can't Tell

RATE THIS SECTION	**STRONG**	**MODERATE**	**WEAK**
See dictionary	1	2	3

D) BLINDING

(Q1) Was (were) the outcome assessor(s) aware of the intervention or exposure status of participants?
Yes
No
Can't tell

(Q2) Were the study participants aware of the research question?
Yes
No
Can't tell

RATE THIS SECTION	**STRONG**	**MODERATE**	**WEAK**
See dictionary	1	2	3

E) DATA COLLECTION METHODS

(Q1) Were data collection tools shown to be valid?
Yes
No
Can't tell

(Q2) Were data collection tools shown to be reliable?
Yes
No
Can't tell

RATE THIS SECTION	**STRONG**	**MODERATE**	**WEAK**
See dictionary	1	2	3

F) WITHDRAWALS AND DROP-OUTS

(Q1) Were withdrawals and drop-outs reported in terms of numbers and/or reasons per group?
Yes
No
Can't tell
Not Applicable (i.e. one time surveys or interviews)

(Q2) Indicate the percentage of participants completing the study. (If the percentage differs by groups, record the lowest).

80 -100%
60 - 79%
less than 60%
Can't tell
Not Applicable (i.e. Retrospective case-control)

RATE THIS SECTION	STRONG	MODERATE	WEAK	
See dictionary	1	2	3	Not Applicable

G) INTERVENTION INTEGRITY

(Q1) What percentage of participants received the allocated intervention or exposure of interest?
80 -100%
60 - 79%
less than 60%
Can't tell

(Q2) Was the consistency of the intervention measured?
Yes
No
Can't tell

(Q3) Is it likely that subjects received an unintended intervention (contamination or co-intervention) that may influence the results?
Yes
No
Can't tell

H) ANALYSES

(Q1) Indicate the unit of allocation (circle one)
community organization/institution practice/office individual

(Q2) Indicate the unit of analysis (circle one)
community organization/institution practice/office individual

(Q3) Are the statistical methods appropriate for the study design?
Yes
No
Can't tell

(Q4) Is the analysis performed by intervention allocation status (i.e. intention to treat) rather than the actual intervention received?
Yes
No
Can't tell

GLOBAL RATING
COMPONENT RATINGS
Please transcribe the information from the gray boxes on pages 1-4 onto this page. See dictionary on how to rate this section.

A	SELECTION BIAS	STRONG	MODERATE	WEAK	
		1	2	3	
B	**STUDY DESIGN**	**STRONG**	**MODERATE**	**WEAK**	

		1	2	3	
C	**CONFOUNDERS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
D	**BLINDING**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
E	**DATA COLLECTION METHOD**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
F	**WITHDRAWALS AND DROPOUTS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	Not Applicable

GLOBAL RATING FOR THIS PAPER (circle one):

1	STRONG	(no WEAK ratings)
2	MODERATE	(one WEAK rating)
3	WEAK	(two or more WEAK ratings)

Final decision of reviewer (circle one):

1 STRONG
2 MODERATE
3 WEAK

Reference: National Collaborating Centre for Methods and Tools

Appendix C

Data Extraction Form/Full Text Review

Data Extraction Form / full text review

This example was used to gather data for a meta-analyses of studies on active learning/traditional/PBL/ teaching strategies/LS in regard to student outcomes, influence and student attitude/perceptions.

- Reference (First author / Year / Journal citation)

- ED-type:
  - Single-Center Undergraduate (#)
  - Single-Center Medical School (#)
  - Multi-Center Professional (#)
  - Multi-Center Pre-Med/Medical School (#)

- Location:
  - Small
  - Medium
  - Large

- Sample size:
  - Intervention population sample (#)
  - Control population sample (#)

- (#) of variables

- Population focus:
  - Medical School population
  - Professional School population (write-in)
  - STEM

- Quality score:
  - Adjustment for confounding variables? (YES/NO)

- Duration of study:

- Study design type:
  - Randomized Controlled
  - Quasi-randomized
  - Cross-sectional
  - Other (write-in)

- Intervention: #
  - (Teaching Strategies)

- Main outcome measures: #
    - (Student Outcomes; Student Attitudes)

- Results:

- Notes (and additional bibliography):

From: http://libguides.gwumc.edu/systematic_review

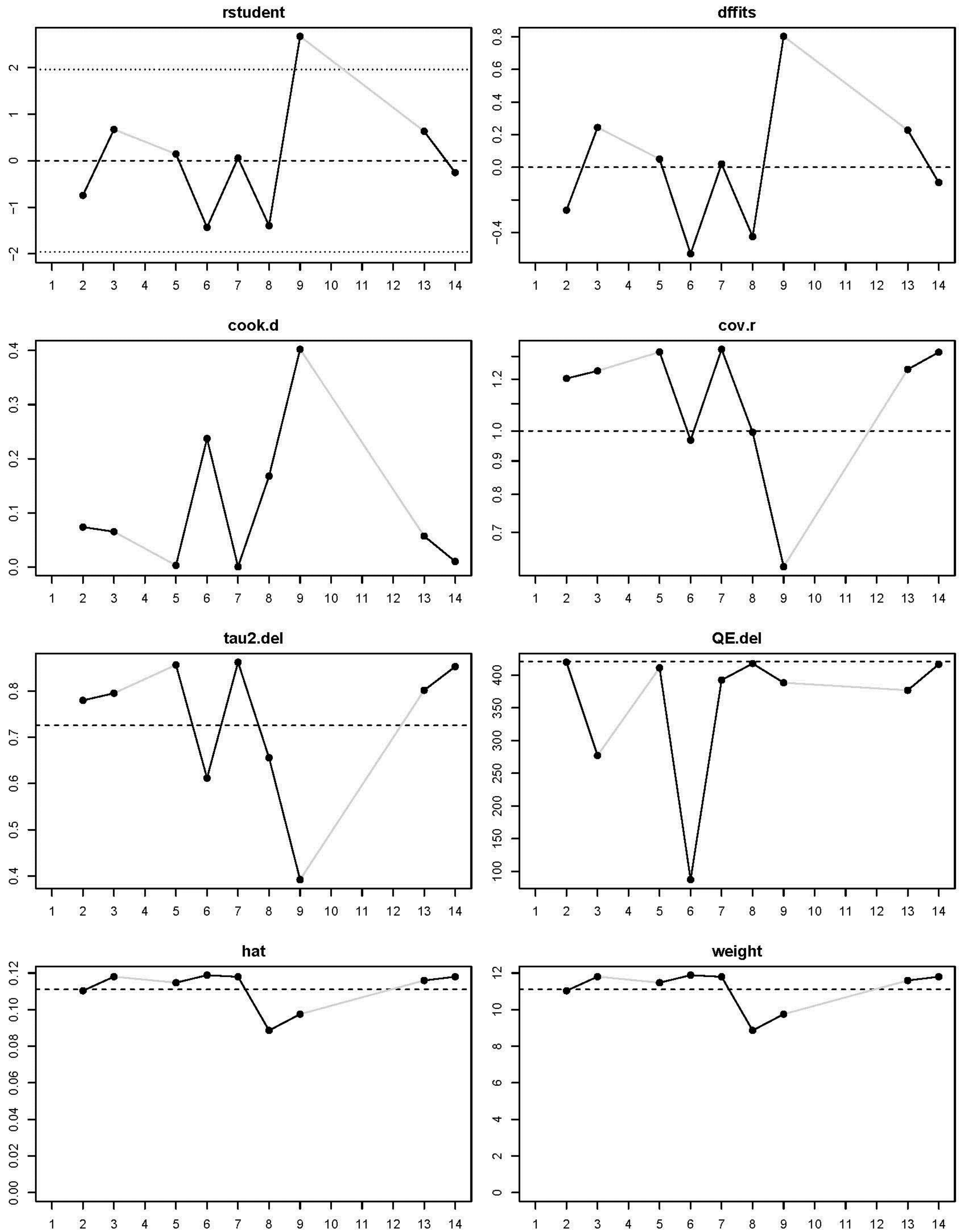
Appendix D

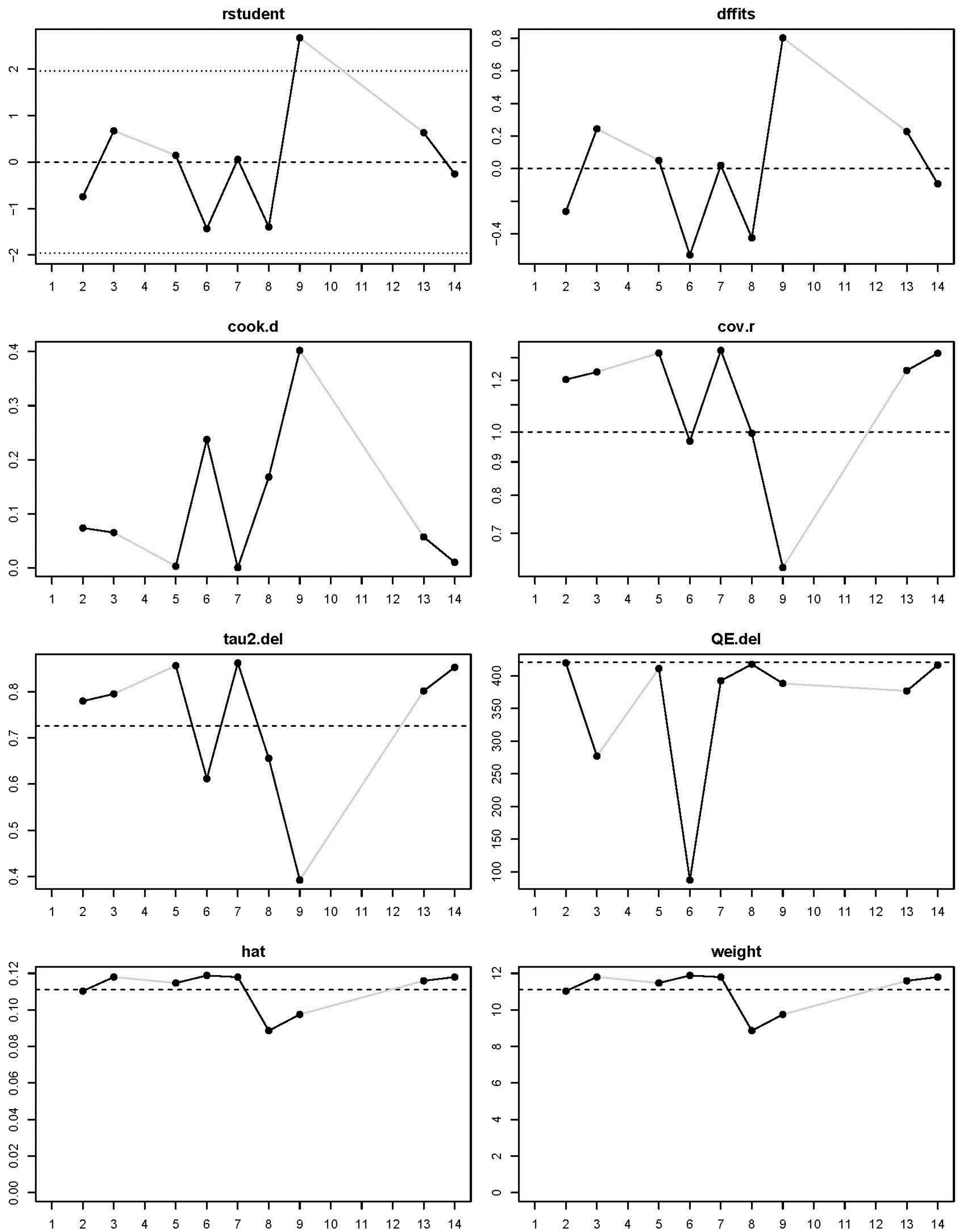
Statistics for Study

	Author	Year	setting	n.c.a	sd.c.a	mean.c.a	n.e.a	sd.e.a	mean.e.a	n.c.k	sd.c.k	mean.c.k	n.e.k	sd.e.k	mean.e.k
2	Nanda	2013	medical school	0	0	0	0	0	0	55.4	0.25	0.56	133	0.28	1.06
3	Khan	2007	medical school	32	27.2	60.7	43	14.6	77.5	32	17.3	58.4	43	20.1	58.4
4	Al.Drees	2003	medical school	275	0.92	3.86	275	0.92	3.48	275	0.85	3.88	275	0.93	4.03
5	Emerald	2013	medical school	49	0	50.44	49	0	66.81	49	0	46.39	49	0	46.94
6	Tucker	2009	medical school	70	6.81	74.97	70	8.56	75.17	70	7.18	75.82	70	6.84	76.07
7	Kuhnigh	2012	medical school	987	0.8	1.7	971	1.3	3	1020	0.7	1.4	1016	0.7	1.5
8	Hagi	2011	medical school	250	1.11	3.56	256	1.04	3.67	250	1.05	3.57	256	0.94	3.86
9	Gowrishankar	2015	medical school	10	1.77	23.5	10	2.24	26.5	10	2.57	5.2	10	1.01	6.35
10	Keiller	2010	medical school	26	3.04	14.92	12	2.71	9.68	26	5.46	22.24	12	6.05	28.87
11	Lucieer 1	2016	medical school	111	0	23.5	66	0	23.8	111	0	33.7	66	0	33.9
12	Lucieer 2	2016	medical school	111	0	23.5	66	0	23.8	111	0	33.7	66	0	33.9
13	Lucieer 3	2016	medical school	139	0	23.5	68	0	24.7	139	0	31.5	68	0	34.1
14	Latif	2014	medical school	92	5.33	23.48	106	4.49	21.58	69	3.24	9.42	58	2.36	7.98
15	Mejias	2015	medical school	257	1.6	6.5	272	1.6	7.1	0	0	0	0	0	0

Appendix E

Meta-Analysis Results


rstudent
dffits
cook.d
cov.r
tau2.del
QE.del
hat
weight


rstudient
dffits
cook.d
cov.r
tau2.del
QE.del
hat
weight
1 2 3 4 5 6 7 8 9 10 11 12 13 14
−2 −1 0 1 2
−0.4 0.0 0.2 0.4 0.6 0.8
0.0 0.1 0.2 0.3 0.4
0.7 0.8 0.9 1.0 1.2
0.4 0.5 0.6 0.7 0.8
100 150 200 250 300 350 400
0.00 0.02 0.04 0.06 0.08 0.10 0.12
0 2 4 6 8 10 12