Spring 2015

Critical thinking skills across the semester in lecture and team-based learning classes

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Critical Thinking Skills Across the Semester

In Lecture and Team-Based Learning Classes

An Honors Program Project Presented to

The Faculty of the Undergraduate

College of Health and Behavioral Studies

James Madison University

In Partial Fulfillment of the Requirements

For the Degree of Bachelor of Science

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May 2015

Accepted by the faculty of the Department of Psychology, James Madison University, in partial fulfillment of the requirements for the Degree of Bachelor of Science.

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Abstract

The purpose of this study was to compare critical thinking and higher-order thinking skills across the semester in lecture and team-based learning classes. Team-based learning classes utilize techniques that were thought to foster an increase in critical thinking and higher-order thinking skills when compared to lecture classes. The Halpern Critical Thinking Assessment S2 (HCTA S2) was used to measure critical thinking skill changes and Bloom's Taxonomy coded higher-order thinking questions on the final exam. Raw score changes on the HCTA S2 and scores on the higher-order thinking questions on the final exam were compared between the two classes. No significant difference was found between the two classes when comparing raw score changes on the HCTA S2. A significant difference was found when comparing number of correct answers on the higher-order thinking application questions on the final exam between the two classes. No such significant difference was found between the two classes on higher-order thinking analysis questions. Finally, a significant negative correlation was found between raw score changes on the HCTA S2 and number of higher-order thinking questions correct on the final exam. There were many limitations in this study, including limited time, strict critical thinking and higher-order thinking definitions, and low student motivation. Future studies should continue to assess the increase in higher-order application skills in team-based learning classes as well as re-asses the effect of class structure on critical thinking skills.

Acknowledgements

I would like to thank Dr. Krisztina Jakobsen for helping me as my thesis mentor and advisor. Secondly, I would like to thank my Thesis Committee members, Dr. Natalie Kerr Lawrence and Dr. Vivien Chan for their help in reviewing, reading, and constructing my thesis. Finally, I would like to thank Dr. Kevin Apple and the JMU Psychology Department for helping me achieve the funding to purchase necessary materials.

Critical Thinking Skills Across the Semester In Lecture and Team-Based Learning Classes

Educators, professors, and researchers alike believe that critical thinking and higher-order thinking are valuable skills for students to develop because of their academic and real-world applications (Browne & Keeley, 1988; Halpern & Nummedal, 1995; Lawson, 1999; Penningroth, Despain, & Gray, 2007). Critical thinking, a component of higher-order thinking (Lewis & Smith, 1993), is a highly sought after educational skill that combines argument analysis and decision-making (Astleitner, 2002; Ennis, 1993; Fisher & Scriven, 1997; Gold, Holman, & Thorpe, 2002; Halpern & Riggio, 2003; McPeck, 1990; Missimer, 1986; Moore, 1989; Morris & Ennis, 1989; Paul & Elder, 2008; Paul, Fisher, & Nosich, 1993) and can be increased through active and collaborative learning (Burbach, Matkin, & Fritz, 2004; Gokhale, 1995; Johnson & Johnson, 1989; Laal & Ghodsi, 2012; Panitz, 1999; Penningroth, et al., 2007; Roberts, 2004).

Critical thinking and higher-order thinking are considered important skills, therefore, it is necessary to examine how they can be promoted in the classroom (Browne & Keeley, 1988). The purpose of this study is to assess changes in critical thinking and higher-order thinking skills as a result of different pedagogical methods**.** Specifically, I examined the impact of Team-Based Learning (TBL; Michaelson, Knight, & Fink, 2002) on changes in critical and higher-order thinking skills throughout the course of a semester, compared to a traditional lecture method.

Team-based Learning

TBL is an instructional strategy that employs active and collaborative learning through a sequence of activities that includes individual work, teamwork, and immediate feedback (Michaelson et al., 2002; Parmelee, Michaelsen, Cook, & Hudes, 2012). TBL's prescribed structure should enhance the learning process through the use of teams and application activities that stimulate and challenge students while promoting higher-order thinking and critical thinking, which include argument analysis and decision-making skills.

The TBL structure includes two main components: the first ensures that students have a solid foundation of the primary course content, while the second requires students to apply the knowledge. The Readiness Assurance Process (RAP) is the basic mechanism to ensure that students learn and understand the primary course content for each unit (Michaelsen et al., 2002). The RAP consists of completing take home assignments for initial exposure to primary course content. In the classroom, students take an individual quiz and then take the same quiz with their teams to ensure they understand the primary course content. A short clarification lecture further ensures students' understanding of the primary course content.

After students complete the RAP for each unit, they work in their teams to complete application activities that require teams to apply course concepts (see Appendix A for an example). The RAP provides students with the foundational understanding of the concepts and prepares them for engaging in stimulating discussion during the application activities (Michaelsen et al., 2002). The application activities are set up in a very specific structure, which allows students to work on the same specific-choice problem, case, or question (Michaelsen et al., 2002). The specific choices are all correct

answers, but students within the teams need to make a decision as to which choice they think is most appropriate (Michaelsen et al., 2002). After choosing an option, teams must provide evidence to support their choice (Michaelsen et al., 2002). Having the same specific-choice questions with all correct answers requires the teams to simultaneously report their answers in order to solidify their commitment to the choice (Michaelsen et al., 2002). After teams simultaneously report their choices, they engage in a debate/discussion in which they must defend their answer. The RAP and the application activities promote components of critical thinking and higher-order thinking, therefore, I expect that TBL students will show greater gains in critical thinking and higher-order thinking than lecture students.

How does TBL promote Higher-Order Thinking and Critical Thinking?

In this section, I will define higher-order thinking and critical thinking and their components as well as describe for each how they may be enhanced through the use of TBL.

Higher-order thinking. Higher-order thinking is a concept with varying definitions (Garrison, et. al, 1999; Lewis & Smith, 1993; Miri, David, & Uri, 2007). For the purpose of my paper, I will refer to higher-order thinking as constructing meaning while yielding multiple solutions, each with costs and benefits, rather than one simple solution (Garrision, et. al, 1999; Paul, 1993; Resnick, 1987).

Identifying higher-order thinking can be done using Bloom's Taxonomy, a framework used to categorize levels of reasoning skills (Bloom, 1956). There are six levels in the taxonomy, which each increase in the level of abstraction and thinking (Bloom, 1956). The first two levels (remembering and understanding) are considered

lower-order thinking because they require straightforward thinking and basic memory and knowledge of concepts, while the latter four levels (application, analysis, synthesis, and evaluation) are considered higher-order thinking because they require abstract thinking that goes beyond basic understanding (Bloom, 1956; Krathwohl, 2002; Paul, 1993). I will be assessing application and analysis questions because these two questions types were the only higher-order thinking questions on the final exam. Application questions involve applying and using knowledge that has been learned to solve a problem (Bloom, 1956). Analysis questions require students to understand and utilize patterns to assess a problem or a concept and come up with a solution based on this assessment (Bloom, 1956).

Studies have shown that higher-order thinking can be increased through challenging questioning that promote abstract thinking (Thomas & Thorne, 2009), classrooms set up to utilize technology in effective ways (Hopson, Simms, & Knezek, 2001), or the use of real-word examples (Miri, et al., 2007). The RAP and application activities utilized in TBL require students to apply knowledge and analyze arguments, which are two components of higher-order thinking, and because the answers could all be correct, it requires a much higher-level of thinking than traditional lecture classes. Due to the structure of TBL, and the higher-order thinking practice students utilize, I expect students in a TBL course to demonstrate greater higher-order thinking than students in a lecture course.

Argument analysis. Argument analysis refers to the evaluation of the validity and credibility of arguments as well as a general skepticism towards statements or knowledge and is considered a component of critical thinking (Blessing & Blessing,

2010; Gold et al., 2002; McPeck, 1990; Missimer, 1986; Moore, 1989; Paul et al., 1993). Argument analysis includes an assertion or proposition, facts or principles given in evidence to support the assertion, and the reasoning that connects these facts to the assertion (Bensley, 2010; Bensley, Crowe, Bernhardt, Buckner, & Allman, 2010; Beyer, 1985; Toulmin, Ricke, & Jarki, 1984; Scriven, 1976). Students who practiced dissecting and evaluating arguments achieved higher gains in general critical thinking skills than students who did not (Blessing & Blessing, 2010). Adam and Manson (2014) found that students who engaged in an argument activity were better at critically evaluating an infomercial with obvious flaws in its claims than students who received lecture instruction.

In TBL, argument analysis can be seen in the RAP through questions on the weekly quizzes. The multiple-choice quiz questions require students to select the best answer for each question. In order to identify the correct answer, students must analyze each answer choice. Argument analysis is also present in the application activities because students are required to assess each arguments' claims and either support or refute it based on their understanding of course content. Additionally, the simultaneous reporting of answers allows students to engage in a debate that should promote argument skills because teams must demonstrate to the class how they can support their claim. Students should develop critical thinking skills as they practice argument analysis skills.

Decision-making. Ennis (1993) defines decision-making as drawing conclusions and developing a position on an issue. Decision-making is a key part of the critical thinking definition and decision-making skills have been shown to be correlated with critical thinking skills, which suggests that as decision-making skills develop, critical

thinking skills will also increase (Brooks & Shepherd, 1990; Cohen, Freeman, & Thompson, 1998; Halpern, 1998; Halpern & Riggio, 2003; Shin, 1998). Researchers have suggested strategies that can be implemented to increase decision-making skills, such as scenario planning (Chermack, 2004), variable identification practice (Van Bruggen, Smidts, & Wierenga, 1998), as well as group discussion techniques such as devils advocate and dialectical inquiry (Schweiger, Sandberg, & Ragan, 1986).

Decision-making in TBL can be found in the RAP process in the quizzes because students must make a decision as to what the correct answer is based on previously acquired knowledge. In the application activities, students again must make a choice but because all of the choices are correct, the decision making process is more challenging. TBL utilizes the same question and specific choice, which allows students to work together while practicing decision-making skills to select and support an answer choice. As with Schweiger et al. (1986), these discussion techniques should increase critical thinking skills as teams discuss their answer choices with other teams and argue against "devils advocates". Teams also discuss different aspects of their answer choice and plan ahead in order to successfully defend their choice in a similar manner as the decision-making practice done in Chermack (2004) and Van Burggen, et al. (1998). As with argument analysis, the daily decision-making practice should increase critical thinking skills for students in the TBL class.

Collaborative and active learning. Studies suggest that critical thinking skills, measured in a general or content-specific format, can be increased over the course of a semester-long instructional course, provided that students have the opportunity to practice (Adam & Manson, 2014; Blessing & Blessing, 2010; Burbach, et al., 2004;

Gokhale, 1995; Penningroth, et al., 2007). In order to achieve increases in critical thinking skills, the classrooms in these studies were set up in such a way that either promoted either collaborative or active learning (Bonwell & Eison, 1991; Gokhale, 1995; Johnson & Johnson, 1989; Laal & Ghodsi, 2012; Panitz, 1999; Penningroth, et al., 2007; Roberts, 2004). Collaborative learning is defined as a situation in which people interact in ways that enhance learning and achieve academic goals (Dillemhourg, 1999; Gokhale, 1995). The goals of collaborative learning include getting students to take responsibility for working together and evolving as individuals and as a group while learning academic information (Dooly, 2008). Collaborative thinking and working together on critical issues are necessary parts of today's academic and professional worlds (Austin, 2000; Laal, Naseri, Laal, & Khattami-Kermanshahi, 2013; Welch, 1998). Studies have shown that students who participate in collaborative learning perform better on critical thinking tests compared to students who participate in individual learning (Gokhale, 1995; Johnson & Johnson, 1989; Laal & Ghodsi, 2012; Panitz, 1999; Roberts, 2004). Groups engaged in small group discussion and active learning achieved greater increases in content-specific psychological critical thinking skills when compared to groups that received standard lecture (Penningroth, et al., 2007).

Additionally, participating in active learning demonstrates increases in critical thinking skills when compared to passive learning (Burbach et al., 2004; Walker, 2003; Youngblood & Beitz, 2001). In a broad definition, active learning is defined as any form of learning in which students engage in an activity that results in concept reflection (Cohn, Atlas, & Ladner, 1994; Linton, Pangle, Wyatt, Powell, & Sherwood, 2014; Prince, 2004). For students to engage in optimal active learning, they must not only

listen, but also read, write, discuss, and engage in problem solving as well as interact with peers (Bonwell & Eison, 1991; Linton, Farmer, & Peterson, 2014). In addition, students should engage in higher-order thinking tasks including analysis, synthesis, and evaluation (Bonwell & Eison, 1991). These studies show that general and content-specific critical thinking skills can increase over the course of a semester if argument analysis, small groups/collaborative learning, or active learning methods are utilized.

Active and collaborative learning can occur in classrooms using lecture based instructional methods by utilizing different engagement and group-work techniques (e.g., Ebert, Brewer, & Allred, 1997; Gokhale, 1995; Prince, 2004; Sokoloff & Thornton, 1997). More time during the typical lecture classroom is devoted to lecturing, which means students may have less time to engage activities that increase critical thinking and higher order thinking skills. In sum, practicing argument analysis and decision-making, and partaking in active and collaborative learning should increase critical thinking skills.

Students in lecture-based classrooms may show gains in critical thinking skills but, because TBL combines active learning and collaborative learning in each class session, while giving students time to practice necessary components of critical and higher order thinking, I predict that students in a TBL class will show greater gains in these skills compared to students in a lecture class (Burbach et al., 2004; Penningroth, et al., 2007; Walker, 2003).

Assessing Higher-Order Thinking and Critical Thinking

Studies have verified that critical-thinking skills can be assessed using multiple-choice tests (Morrison & Free, 2001; Morrison, Smith, & Britt, 1996; Tractenberg, Gushta, Mulroney, & Weissinger, 2012) as well as through short-answer essay tests

(Stein, Haynes, Redding, Ennis, & Cecil, 2007). For the purposes of my study, I will assess critical thinking using multiple-choice questions. If the multiple-choice questions require higher-order and multi-logical thinking, a high-level of discrimination between plausible alternatives, and include rationale for each test items, then students who are better at critical thinking would be more likely to get them correct (Morrison & Free, 2001; Morrison et al., 1996; Tractenberg, et al., 2012).

To assess general critical thinking skills, I will use Halpern's Critical Thinking Assessment (HCTA S2), which has been validated as a measurement tool of general critical thinking skills (Butler, 2012; Marin & Halpern, 2011; Halpern, 2006). The HCTA S2 tests five components of critical thinking: decision making and problem solving; thinking as hypothesis testing; argument analysis; likelihood and uncertainty; and verbal reasoning (Halpern, 2010). The test yields an overall general critical thinking score based on these five components.

To assess content-specific higher-order thinking skills, I will use multiple-choice questions from a textbook test bank that have been coded using Bloom's Taxonomy (Bloom, 1956; Krathwohl, 2002; Paul, 1993), specifically at the application and analysis level (see Appendix B for examples). Critical thinking is a key component of higher-order thinking, therefore, I assume that scores on the higher-order thinking questions would be related to students' critical thinking.

Research Question and Hypothesis

Two classes, one TBL and one lecture, were compared on changes in critical thinking skills between the beginning and the end of the semester. The teaching techniques utilized in TBL promote argument analysis and decision-making and students

work actively and collaboratively during each class period, which is why I expect that students in a TBL class will show greater increases in critical thinking skills during the course of the semester compared to students in a lecture class. I also believe that higher-order thinking skills will increase in the TBL class because critical thinking is a component of higher-order thinking (Lewis & Smith, 1993). I have three specifics hypotheses. (1) Because active and collaborative learning (Burbach, Matkin, & Fritz, 2004; Gokhale, 1995; Johnson & Johnson, 1989; Laal & Ghodsi, 2012; Panitz, 1999; Penningroth, et al., 2007; Roberts, 2004), as well as argument analysis, decision making, and higher-order thinking practice, have been proven to increase critical thinking skills (Astleitner, 2002; Ennis, 1993; Fisher & Scriven, 1997; Gold, Holman, & Thorpe, 2002; Halpern & Riggio, 2003; McPeck, 1990; Missimer, 1986; Moore, 1989; Morris & Ennis, 1989; Paul & Elder, 2008; Paul, Fisher, & Nosich, 1993), I predict that students in TBL will show larger gains in critical thinking skills compared to students in the lecture class. (2) I also believe that students in the TBL class will achieve higher scores on the higher-order thinking questions on the final exam than students in the lecture class because of the increased amount of critical thinking and higher-order thinking practice in which they will have engaged throughout the semester in the RAP and application activities. (3) I also believe that there will be a positive correlation between HCTA S2 skills and higher-order thinking scores (application and analyze), because critical thinking is a component of higher-order thinking.

Methods

Participants

Two classes were evaluated during this study, both James Madison University developmental psychology courses taught by Dr. Krisztina Jakobsen during fall 2014. Total, there were 64 students across the two classes. Students who dropped the class (n=2), did not give permission for their data to be used (n=1), and who did not allow for GPA verification, were excluded (n=3). The final sample consisted of 58 students. The lecture class met on Monday, Wednesday, and Friday at 9:00 a.m., and had 30 students (3 male and 27 female) with an average age of 20.13 (SD = .78), and an average GPA of 3.21 (SD = .45). The TBL course also met on Monday, Wednesday, and Friday but at 10:00 a.m., and had 28 students (9 male and 18 female) with an average age of 20.4 (SD = .95), and an average GPA of 3.23 (SD = .45).

Materials

Halpern Critical Thinking Assessment. The general critical thinking test that was used in this study was the HCTA S2. For this study, the S2 version of the assessment was used which contained only forced-choice questions in an online format. The test consisted of 25 everyday scenarios, followed by a series of multiple-choice questions. It measures recognition of five facets of critical thinking ability: decision making and problem solving; thinking as hypothesis testing; argument analysis; likelihood and uncertainty; and verbal reasoning. The HCTA S2 takes about 20 minutes to complete but there was no time limit for either the individual items or the entire test. The HCTA S2 has a Cronbach α of .79 (Halpern, 2010), revealing that the HCTA S2 test has high reliability, and is therefore, a precise measurement of critical thinking.

Content-specific critical thinking. Students completed a final exam for the Developmental Psychology course that contained multiple-choice questions that measured lower- (remembering and understanding) and higher-order thinking (analyze and apply). The final exam drew from a textbook test bank that contained multiple-choice questions coded according to Bloom's taxonomy. The number of correct responses on the higher-order questions was assessed and compared between classes. There were 16 application higher-order thinking questions and 18 analysis higher-order thinking questions.

Procedures

Students in both classes completed the HCTA S2 during the first week of the semester. During the final week of classes, students completed the HCTA S2 again. Each pre- and post-test was worth 15 points out of a possible 1000 points for the students' final grades. Finally, the professor gave the students a cumulative final exam at the end of the semester that assessed their Developmental Psychology knowledge.

Data analysis.

Change in critical thinking skill was calculated by subtracting raw score on the HCTA S2 post-test from the HCTA S2 pre-test. The resulting number represents the change in critical thinking skill throughout the semester as assessed by the HCTA S2. The total number of higher-order thinking application and analysis questions answered correctly on the final exam were used to represent level of higher-order thinking.

Results

Critical Thinking

To test the difference in pre- and post-test raw scores of critical thinking, I used a two sample *t*-test that revealed no significant difference between lecture (M = .689, SD = 6.536) and TBL (M = .259, SD = 5.111), $t(52) = .275$, $p = .784$, $d = 0.072$ (Table 1). An ANCOVA revealed no significant interaction between class and GPA, so we can assume the regression slopes are homogenous, $F(1,40) = .003$, $p = .954$. After controlling for GPA, there was no significant difference in raw score changes between the lecture and TBL class, $F(1,41) = .221$, $p = .641$, $\eta_p^2 = 0.005$.

Table 1

Critical Thinking and Higher-Order Thinking Results

	HCTA S2 (Critical Thinking)		**Final Exam (Higher-Order Thinking)**	
	Pre-Test Mean	**Post-Test Mean**	**Mean Application Questions Answered Correctly**	**Mean Analysis Questions Answered Correctly**
Lecture	66.966	67.655	11.813	11.063
	(6.684)	(5.845)	(1.731)	(1.722)
TBL	68.556	68.815	12.677	10.645
	(6.969)	(5.677)	(2.136)	(1.54)

Note, standard deviations were given below the means in parentheses.

Higher-Order Thinking

To test the effect of class type (lecture and TBL) on higher-order thinking application score on the final exam, I used an ANCOVA which revealed no significant

interaction between class and GPA, so we can assume the regression slopes are homogenous, $F(1,54) = .006$, $p = .939$. There was a significant effect of class type (lecture and TBL) on higher-order thinking application score on the final exam after controlling for GPA, $F(1,55) = 7.451$, $p = .008$, $\eta_p^2 = 0.119$.

To test the effect of class type (lecture and TBL) on higher-order thinking analysis score on the final exam, I used an ANCOVA which revealed no significant interaction between class and GPA, so we can assume the regression slopes are homogenous, $F(1,54) = 1.72$, $p = .195$. There was no effect of class type (lecture and TBL) on higher-order thinking analysis score on the final exam after controlling for GPA, $F(1,55) = 1.033$, $p = .314$, $\eta_p^2 = 0.018$.

Correlations

To test the correlation between difference in pre- and post-test raw scores and higher-order thinking application score, I used a Pearson Correlation, which revealed a significant, negative correlation between scores on the application questions and the change in HCTA S2 scores, $r = -.307$, $p = .038$. To test the correlation between difference in pre- and post-test raw scores and higher-order thinking analysis score, I used a Pearson Correlation test and a significant, negative correlation was found between scores on the analysis questions and the change in HCTA S2 scores, $r = -.364$, $p = .013$.

Discussion

In summary, my results show that students in the TBL class and lecture class both showed gains in critical thinking skills at the end of the semester, although they were not significantly different from each other, which does not support my hypothesis. Students in the TBL class earned higher scores on the application higher order thinking questions on the final exam compared to students in the lecture class, supporting my proposed hypothesis, but there were no differences on the analysis higher order thinking questions, which does not support my hypothesis. Finally, I found negative correlations between critical thinking skill gains and application higher-order thinking scores as well as analysis higher-order thinking scores, which also do not support my initial hypothesis.

Critical Thinking

I found no significant differences between raw score changes in critical thinking between the two classes. One explanation may be that TBL does not increase critical thinking skills like I hypothesized. I assumed that TBL would increase critical thinking skills because research suggests that the components in TBL (e.g. argument analysis and decision-making) contribute to critical thinking; however, the RAP and application activities did not seem to generate changes in general critical thinking skill. TBL only implicitly instructs critical thinking and some research shows that explicit instruction is needed to show the greatest gains (Marin & Halpern, 2011). Explicit critical thinking instruction involves: the development of argument analysis skills; correlation and causation distinction practice; stereotype identification practice; and the continued practice of assessing long-term consequence of decision-making (Halpern, 2010). Implicitly teaching critical thinking skills can be accomplished by imbedding critical

thinking skills in instruction and allowing the students to engage in critical thinking skill practice without direct instruction (Halpern, 2010). TBL allows students to practice most of these skills but does not explicitly teach critical thinking using the above methods.

Also, one semester may not have been enough time for TBL to increase critical thinking skills. If the testing had gone on for a year, instead of a semester, I might have seen different results. Testing effects may have influenced our results because both the pre- and post-tests used the same questions and research shows that repeated testing can increase scores due to repetition and practice (Kromann, Jensen, & Ringsted, 2009; McDaniel, Anderson, Derbish, & Morrisette, 2007). Students taking the post-test may have been influenced by their initial pre-test answer choices. Although the HCTA has been used as both a pre- and post-test, the HCTA S2 alone has not been used as both the pre- and post-test (Halpern, 2010). Another explanation may be that the students were not as motivated during the second round of critical thinking testing, which occurred at the end of the semester. The pre- and post-tests were only worth a small portion of the students' overall grades (15 out of 1000 for each), which is a small amount of extrinsic motivation. Two major disadvantages of using solely extrinsic motivation are that performance is dependent on each student's definition of a "good grade" and that large amounts of extrinsic motivation are needed initially (Bain, 2004). Fifteen points out of 1000 may not have been a large enough amount of points to properly motivate the students. The experiment could have also been set up in a way that showed the students the importance in trying hard for both tests, which may have also helped change the results. However, this explanation is not likely, increasing motivation (intrinsic or

extrinsic) equally in both classes may not change the results of the study because both classes would have equal increases in motivation.

My definition of critical thinking focused on two main components: argument analysis and decision-making, but the HCTA S2 assessed a total of five critical thinking facets: decision making and problem solving; thinking as hypothesis testing; argument analysis; likelihood and uncertainty; and verbal reasoning (Halpern, 2010). If TBL only helped students practice argument analysis and decision-making, the students may not have practiced the other necessary critical thinking components assessed by the HCTA S2. Also, the HCTA S2 measured general critical thinking skills and the students may have only learned content-specific critical thinking skills, which did not transfer over to general critical thinking skills. Some studies that have assessed critical thinking skill changes used content-specific tests to measure specific critical thinking skill changes in case general critical thinking skills are too difficult to promote in a classroom setting (Penningroth, et al., 2007). Finally, my definition of critical thinking only focused on argument analysis and decision-making but other studies have found that critical thinking includes other factors such as application and synthesis (Gokhale, 1995), meaningful understanding, (Garrison, et al., 1999), and interpretation and explanation (Facione, 1998). My concise definition of critical thinking may have contributed to the limited findings resulting from my study.

Higher-Order Thinking

When assessing the effect of class type on higher-order thinking application score on the final exam, I found a significant effect, in which students in the TBL class had higher scores on the higher-order thinking application questions on the test compared to

students in the lecture class. Research suggests this would be the case because if students practice critical thinking skills all semester (like they do in TBL in the RAP and application activities), they would be expected to do better on higher-order thinking questions (Lewis & Smith, 1993; Miri, et. al, 2007). The significant result obtained from higher-order thinking application score suggests that TBL promoted an increase in application skills, which should be explored further because that may mean that TBL allows students the opportunity to practice important higher-order thinking skills. One potential limitation that arises out of this finding is that the application activities are the only component of TBL that actually increases critical thinking skills.

However, this promising result was not seen in higher-order thinking analysis scores on the final exam, which revealed no effect of class type. One of the explanations as to why there was a significant effect of application and not analysis is that TBL explicitly practices application skills in the application activities (Michaelsen et al., 2002) but only implicitly practices analysis skills. A limitation arises involving these two types of higher-order thinking questions because I, personally, did not code them as application and analysis questions. An outside rater coded the questions for the testbank, but without explanation of the criteria for application and analysis questions.

Correlations

I also found that raw score changes on the HCTA S2 negatively correlated with both scores on analysis and application higher-order thinking questions on the final exam. Research would suggest that if students do well on critical thinking questions, they should also do well on higher-order thinking questions, but that is not what I found. One reason for this finding could be that critical thinking is not the only component of higher-

order thinking. Some studies have found that higher-order thinking includes components such as taking in new information and committing it to memory to be used as possible answers to perplexing situations, (Lewis & Smith, 1993) and the application of criteria to yield multiple solutions (Zohar & Dori, 2003) in addition to critical thinking (Garrision, et. al, 1999; Paul, 1993; Resnick, 1987). Critical thinking is not the only facet of higher-order thinking, which means simply increasing critical thinking skills may not increase higher-order thinking skills.

I also compared general critical thinking scores with content specific higher-order thinking scores, which may have been another potential limitation. Students worked all semester on content-specific information, which may have influenced their higher-order thinking scores without changing their general critical thinking scores. One study found that there is a very weak, but significant correlation, between general and content-specific critical thinking tests (Reid, 2000). This weak correlation implies that comparing general scores to content-specific scores may not always result in a significant correlation, which makes this comparison a limitation of this study.

Future Directions

There are many improvements and additions that could be implemented to help counteract the limitations in my study. Although using multiple-choice questions is more time-efficient, it may not be the best way to assess critical thinking and higher-order thinking, which means that future studies could try using tests that utilize short-essay questions. Short-essay questions have advantages over multiple-choice questions, such as students cannot guess the correct answer and students employ deep learning approaches (deep strategies and motives) when answering essay questions compared to

multiple choice questions, which could inspire deeper and more critical thinking (Scouller, 1998). TBL students practiced argument analysis and decision-making skills, which may not have shown up on the multiple-choice tests, but may have been able to be assessed using short-essay questions. I also only used one measure of critical thinking, the HCTA S2. Future studies could use multiple critical thinking tests in order to capture all components of the broad concept.

Additional studies could also assess the importance of the application activities because application scores were the only component of higher-order thinking found to differ between the TBL class compared to the lecture class. A study could be designed that compares two halves of a lecture class in which one half participates in individual application activities and the other does not. If an increase in application skills is found in the former group, then it may be the case that just the application activities, not TBL as a whole, increase application higher-order thinking skills.

The study could have also been altered to compare correlations between general critical thinking skills and general higher-order skills as well as compare correlations between content-specific critical thinking skills and content-specific higher-order thinking skills. This change would hopefully alter the negative correlation obtained between general critical thinking skills and content-specific higher-order thinking skills. Finally, critical thinking skills could have been explicitly taught, instead of implicitly practiced (Marin & Halpern, 2011). Explicitly instructing and practicing critical thinking involves the teacher elaborating on the individual components of critical thinking and then working with the students to learn, practice, and eventually master the components (Halpern, 2010).

In sum, my study suggests that TBL can promote a type of higher-order thinking (application) in content-specific questions, but not necessarily increase general critical thinking skills. This may mean that TBL components (RAP and application activities) align with higher-order thinking more so than critical thinking.

Appendix A

Sample Application Activity

Cognitive Development Theories

Learning objective:

1. Describe the components of sociocultural and dynamic systems theories.
2. Explain the influences of each of the previous theories (Piagetian, information processing, sociocultural) on dynamic systems theories.

Instructions: Answer the questions below.

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1. Imagine that you are teaching a parenting course and will have time to teach only one of the concepts below. Which one would you choose? Explain.

    A. Zone of proximal development
    B. Social scaffolding
    C. Guided participation

2. Today's theorists, recognizing both consistency and variability in children's development, have adopted a dynamic systems perspective—a view in which the child's mind, body, and physical and social worlds form an integrated system that guides mastery of new skills. All of the following are key features of dynamic systems theories. Which one is the most defining feature?

    A. The concept of self-organization
    B. Variation and selection
    C. The emphasis on children's own motivation to learn about the world
    D. The importance of children's observations and imitations of others

3. Dynamic systems theories reflect influences of each of the other theories reviewed in this chapter. Which theoretical influence do you think is the strongest? Provide 3 reasons for why you chose the theory you chose (be sure you clearly demonstrate the connection between the theories). As you make your decision, think beyond surface level similarities such as whether theories are continuous or discontinuous.

    A. Sociocultural
    B. Piagetian
    C. Information processing

Appendix B

Sample Test Questions

* Note, the underlined answer is the correct answer.

Application Questions

____ 1. Bernard believes that his intelligence is fixed and that there is little he can do to change it. When Bernard encounters failure, he would be expected to:
A) work persistently to solve the problem.
B) believe that his failure is due to a lack of effort.
C) believe he is still smart regardless of the failure.
D) feel helpless.

___ 2. Annalee is 3 years old. If asked to describe herself, which statement is she LEAST likely to say?
A) "I am a great dancer. See, I can do a pirouette."
B) "I love to go apple picking."
C) "I have brown hair."
D) "My sister is a faster runner than me."

Analysis Questions

____ 3. The dynamic-systems approach is intended to counter which disadvantage of other theories of cognitive development?
A) inability to explain infants' apparent innate knowledge of some domains
B) lack of emphasis on how others help children learn
C) lack of attention to strategic variability
D) impression that children's thinking and their actions are independent

____ 4. Which statement about the contribution of psychoanalytic theories to psychology is true?
A) Psychoanalytic theories have yielded important practical applications, such as the procedure of systematic desensitization.
B) The importance placed on subjective experience is now viewed as outdated.
C) The specifics have been scientifically tested and supported.
D) The emphasis on early experience has endured into current views of development.

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