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

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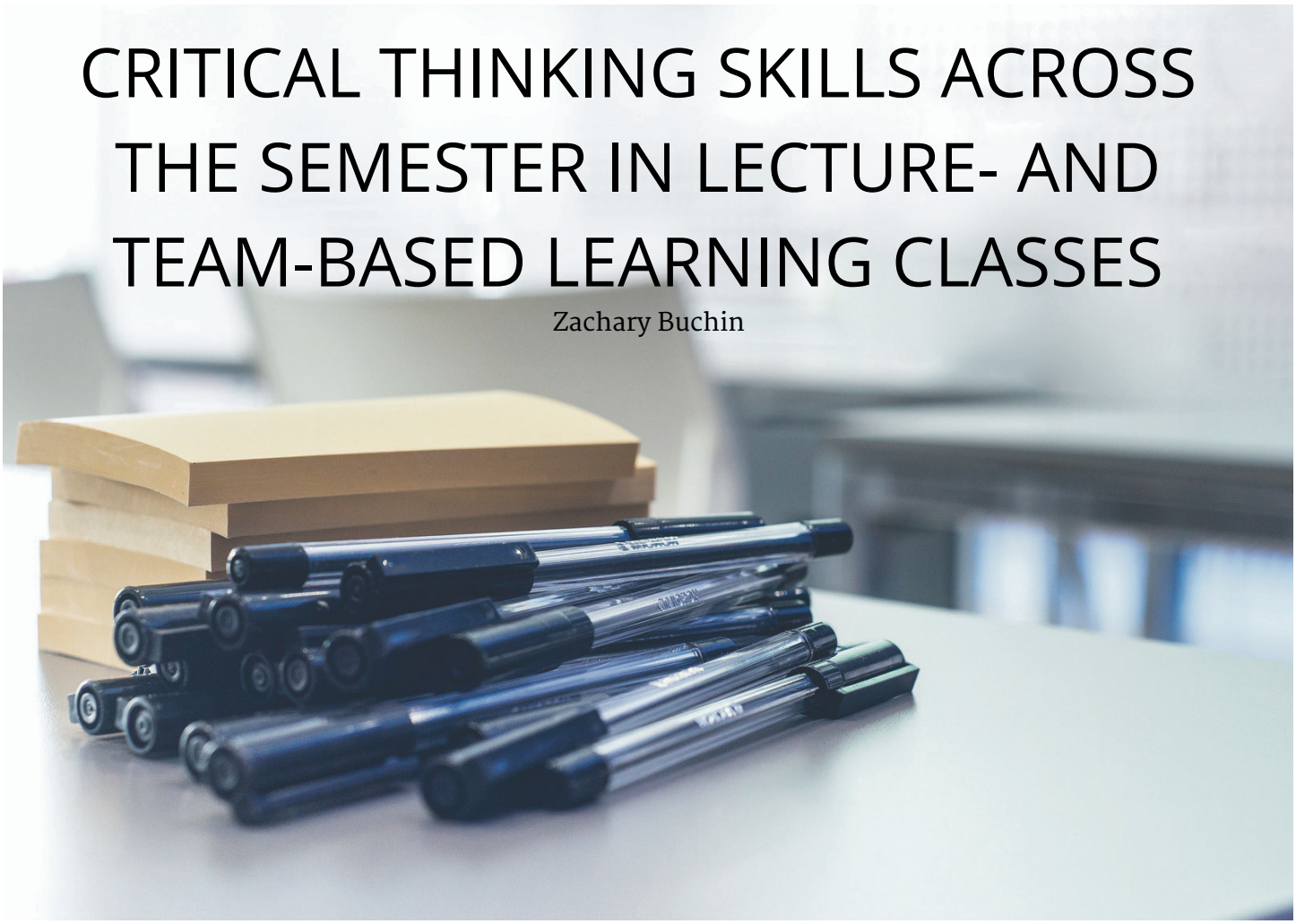

ABSTRACT

Team-based learning (TBL) classes utilize techniques believed to foster increases in critical and higher-order thinking skills when compared to lecture classes. This study compares increases in critical and higher-order thinking skills in a TBL class and a lecture class covering identical subject matter and taught by the same professor during a single semester. Raw score changes on the the Halpern Critical Thinking Assessment S2 (HCTA S2) were used to measure critical thinking skill changes and Bloom's Taxonomy was used to differentiate higher-order questions on the final exam. No significant difference was found between the two classes when comparing raw score changes on the HCTA S2 or higher-order thinking analysis questions. A significant difference was found when comparing the number of correct answers on the higher-order thinking application questions on the final exam. A significant negative correlation was found between raw score changes on the HCTA S2 and correct higher-order thinking questions on the final exam. These findings suggest the need for future studies that assess the increase in higher-order application skills in team-based learning classes and reassess the effect of class structure on critical thinking skills.

Educators, professors, and researchers alike believe that critical 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). Although the exact definition of critical thinking is widely debated, most agree that it is a component of higher-order thinking (Lewis & Smith, 1993), a 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). Critical thinking 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 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 was 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) on changes in critical and higher-order thinking skills throughout the course of a semester compared to a traditional lecture method (Michaelson, Knight, & Fink, 2002).

LITERATURE REVIEW

TEAM-BASED LEARNING

TBL is an instructional strategy that employs active and collaborative learning through a sequence of activities which 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 teamwork and application activities. These styles of learning 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 in the primary course content, while the second requires students to apply the knowledge. The Readiness Assurance Process (RAP) is a basic mechanism used in TBL which ensures 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. 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).

After students complete the RAP for each unit, they work in their teams to complete activities that require teams to apply course concepts (see Appendix A for an example). The application activities are set up in a structure that 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 decide which option they think is most appropriate (Michaelsen et al., 2002). After choosing, teams must provide evidence to support their decision (Michaelsen et al., 2002). Having the same specific-choice questions with all correct answers requires the teams to simultaneously report their answers and solidify their commitment to the choice (Michaelsen et al., 2002). After teams simultaneously report their choices, they engage in a debate which requires them to defend their answer. The RAP and the application activities promote components of critical thinking and higher-order thinking; therefore, I expected that TBL students would show greater gains in critical thinking and higher-order thinking than lecture students.

TBL, HIGHER-ORDER THINKING, AND CRITICAL THINKING

This section elaborates on the key components of higher-order and critical thinking and describes how each may be enhanced with TBL.

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

Identifying higher-order thinking can be done by using Bloom's Taxonomy, a framework used to categorize levels of reasoning skills (Bloom, 1956)[1]. There are six levels in the taxonomy, which gradually increase in the level of abstraction and thinking (Bloom, 1956). Knowledge

1 Although the current study uses the original Bloom's Taxonomy (Bloom, 1956), it should be noted that Anderson and Krathwohl developed a revised taxonomy in 2000, focusing on the dynamic nature of cognitive processing. Although the revised version uses verbs instead of nouns for category labels, the two taxonomies are similar in terms of content. Because of the many similarities, only the original taxonomy will be used in the current study.

and comprehension are considered lower-order because they require straightforward thinking and basic memory, while application, analysis, synthesis, and evaluation are considered higher-order because they require abstract thinking that goes beyond basic understanding (Krathwohl, 2002; Paul, 1993; see Bloom (1956) for more detail on each individual level). I assessed only application and analysis questions on the exam because synthesis and evaluation questions were not present. Application questions involve applying and using previously gained knowledge to solve a problem. Analysis questions require students to understand and utilize patterns to assess and solve a problem or a concept (Bloom, 1956).

Studies have shown that higher-order thinking can be increased through challenging questioning that promote abstract thinking (Thomas & Thorne, 2009), classrooms that effectively utilize technology (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. 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, students in a TBL course should demonstrate better higher-order thinking than students in a lecture course.

Argument analysis. A second key component of critical and higher-order thinking is the ability to fairly and thoroughly analyze text (e.g., Blessing & Blessing, 2010). Argument analysis refers to the evaluation of the validity and credibility of arguments as well as a general skepticism towards statements of knowledge (Blessing & Blessing, 2010; Gold et al., 2002; McPeck, 1990; Missimer, 1986; Moore, 1989; Paul et al., 1993). Argument analysis includes assertions or propositions followed by facts or principles, which are given in evidence to support the assertions (Bensley, 2010; Bensley, Crowe, Bernhardt, Buckner, & Allman, 2010; Beyer, 1985; Toulmin, Ricke, & Jarki, 1984; Scriven, 1976). Blessing and Blessing (2010) found that students who practiced dissecting and evaluating arguments achieved higher gains in general critical thinking skills than students who did not. 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 is prevalent in the RAP weekly quizzes. The multiple-choice quiz questions require students to select the best answer for each question. Students must analyze each answer choice in order to identify the correct answer. Argument analysis is also present in the application activities because students are required to assess each argument's 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 promotes 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. Studies suggest that decision-making skills are correlated with critical thinking skills, which implies that as decision-making abilities 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), and group discussion techniques such as being a "devil's advocate" and using logical inquiry (Schweiger, Sandberg, & Ragan, 1986).

The quizzes used in TBL's RAP focus on decision-making. Specifically, students must work together to establish the correct answer based on previously acquired knowledge. In the application activities, students again must make a choice, but because all of the choices could be 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. According to Schweiger et al. (1986), these discussion techniques should increase critical thinking skills as teams discuss their answer choices with other teams and argue against devil's advocates. Teams also discuss different aspects of their answer choice and plan ahead to successfully defend their choice against counter-arguments. This team-based decision-making is similar to the scenario planning (Chermack, 2004) and variable identification practice (Van Bruggen et al., 1998) mentioned earlier. 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 increase critical thinking skills, the classrooms in these studies were set up to promote 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 (Dillembourg, 1999; Gokhale, 1995). The goals of collaborative learning include students taking responsibility for working together and evolving as individuals and as a group (Dooly, 2008).

Collaborating on critical issues is a necessary part of today's academic world (Austin, 2000; Laal, Naseri, Laal, & Khattami-Kermanshahi, 2013; Welch, 1998). Studies have shown that students who participate in a 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 discussion and active learning displayed greater increases in content-specific psychological critical thinking components, such as analysis and application, when compared to groups that received a standard lecture (Penningroth et al., 2007).

Additionally, participating in active learning produces increases in critical thinking skills when compared to passive learning (Burbach et al., 2004; Walker, 2003; Youngblood & Beitz, 2001). As 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). Therefore, general and content-specific critical thinking skills should increase over the course of a semester if argument analysis, small group/collaborative learning, or active learning methods are utilized.

Engagement and group work techniques allow for active and collaborative learning in lecture-based classes (e.g., Ebert, Brewer, & Allred, 1997; Gokhale, 1995; Prince, 2004; Sokoloff & Thornton, 1997). Since more time during the typical lecture classroom is devoted to lecturing, students may have less time to engage in activities that increase critical 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.

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. Therefore, I predicted that students in a TBL class would show greater gains in critical thinking skills compared to students in a lecture-based 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 short-answer essay tests (Stein, Haynes, Redding, Ennis, & Cecil, 2007). For the purposes of my study, I assessed critical thinking using multiple-choice questions. If the multiple-choice questions require higher-order and multi-logical thinking as well as a high level of discrimination between plausible alternatives, students who are better at critical thinking will 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 used Halpern's Critical Thinking Assessment (HCTA S2), which has been validated as a measurement tool of general critical thinking skills (Butler, 2012; Halpern, 2006; Marin & Halpern, 2011). 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 used 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 assumed that scores on the higher-order thinking questions will be related to students' critical thinking.

RESEARCH HYPOTHESES

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 as students work actively and collaboratively during each class period. These aspects of TBL led me to expect that students in a TBL class would show greater increases in critical thinking skills during the course of the semester compared to students in a lecture class. I also believed that higher-order thinking skills would increase in the TBL class because critical thinking is a component of higher-

order thinking (Lewis & Smith, 1993). I had three specific hypotheses: (1) Because active and collaborative learning, as well as argument analysis, decision making, and higher-order thinking practice have been proven to increase critical thinking skills, I predicted that students in TBL would show larger gains in critical thinking skills compared to students in the lecture class. (2) I believed that students in the TBL class who regularly practice higher-order thinking would achieve higher scores on the final exam's higher-order thinking questions compared to students in the lecture class. (3) I expected that there would be a positive correlation between HCTA S2 skills and higher-order thinking scores (application and analysis), because critical thinking is a component of higher-order thinking.

METHODS

PARTICIPANTS

For this study, I tested both James Madison University developmental psychology courses taught by Dr. Krisztina Jakobsen during the fall of 2014. There were 64 students across the two classes. Students who either dropped the class (n = 2), did not give permission for their data to be used (n = 1), or did not allow for GPA verification (n = 3) were excluded. The final sample consisted of 58 students. The lecture class met on Mondays, Wednesdays, and Fridays 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 met on Mondays, Wednesdays, and Fridays 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 used in this study was the HCTA S2. This version 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 which measured lower- and higher-order thinking. Exam questions came 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 level was calculated by subtracting the raw score on the HCTA S2 pre-test from the

TABLE 1

CRITICAL THINKING AND HIGHER-ORDER THINKING RESULTS

	Pre-Test Mean	Post-Test Mean	Mean Application Questions Answered Correctly	Mean Analysis Questions Answered Correctly
Lecture	66.966 (6.684)	67.655 (5.845)	11.813 (1.731)	11.063 (1.722)
TBL	68.556 (6.969)	68.815 (5.677)	12.677 (2.136)	10.645 (1.54)

Note. Standard deviations are given below the means in parentheses.

HCTA S2 post-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 was 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, shown in Table 1, I used a two-sample t-test which revealed no significant difference between the lecture class (M=.689, SD=6.536) and TBL class (M=.259, SD=5.111), $t(52)=.275$, $p=.784$, $d=0.072$. An ANCOVA test 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, $F(1,41)=.221$, $p=.641$, $\eta p2=0.005$.

HIGHER-ORDER THINKING

To test the effect of class type (lecture and TBL) on higher-order thinking application scores 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, $F(1,55)=7.451$, $p=.008$, $\eta p2=0.119$.

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 the higher-order thinking analysis score on the final exam after controlling for GPA, $F(1,55)=1.033$, $p=.314$, $\eta p2=0.018$.

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

My results indicate that students in both the TBL class and the lecture class showed gains in critical thinking skills at the end of the semester. These gains were not significantly different, which did not support my first hypothesis. Students in the TBL class earned higher scores on the application of higher-order thinking questions on the final exam compared to students in the lecture class, supporting my second hypothesis. However, there were no differences on the analysis of higher-order thinking questions, which does not support the 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 third 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 a number of components: the development of argument analysis skills; correlation and causation distinction practice; stereotype identification practice; and long-term consequence practice (Halpern, 2010). Implicitly teaching critical thinking skills can be accomplished by embedding 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, there might have been different results. Additionally, 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. However, 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. Additionally, 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. Students in the TBL class had higher scores on the higher-order thinking application questions compared to students in the lecture class. Research suggests this would be the case because if students practice critical thinking skills all semester (as 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. These results suggest 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 increases critical thinking skills.

This promising result was not seen in the higher-order thinking analysis scores on the final exam (i.e., no difference in scores between class types). 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 did not code them as application and analysis questions. The outside rater, who coded the questions for the test bank, did not offer and was not asked to explain the criteria used to distinguish between 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. Specifically, higher scores on critical thinking questions were related to lower scores on higher-order thinking questions. 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 (Garrison et al., 1999; Paul, 1993; Resnick, 1987). The new information could be used as an answer to a perplexing situation (Lewis & Smith, 1993) or to yield multiple solutions (Zohar & Dori, 2003). 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 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 the 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. Future studies could try using tests that utilize short-essay questions. Short-essay questions have advantages over multiple-choice questions: students cannot simply guess the correct answer and thus employ deep learning approaches (deep strategies and motives) (Scouller, 1998). TBL students practiced argument analysis and decision-making skills, which may not have shown up on the multiple-choice tests but could have been 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 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 and 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 the application activities alone—rather than TBL—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 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. These results may mean that TBL components (RAP and application activities) align with higher-order thinking more than critical thinking.

REFERENCES

Adam, A., & Manson, T. M. (2014). Using a pseudoscience activity to teach critical thinking. *Teaching of Psychology, 41*(2), 130-134. doi:10.1177/0098628314530343.

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York, NY: Longman.

Austin, J.E. (2000). Principles for partnership. *Journal of Leader to Leader, 18*, 44-50.

Bain, K. (2004). *What the best college teachers do*. Cambridge, MA: Harvard University Press.

Bensley, D. A. (2010). A brief guide for teaching and assessing critical thinking in psychology. *Observer, 23*(10), 49-53.

Bensley, D. A., Crowe, D. S., Bernhardt, P., Buckner, C. & Allman, A. L. (2010). Teaching and assessing critical thinking skills for argument analysis in psychology. *Teaching of Psychology, 37*, 91-96. doi:10.1080/00986281003626656

Beyer, B. K. (1985). Critical thinking: What is it. *Social Education*, *49*(4), 270-276.

Blessing, S. B., & Blessing, J. S. (2010) PsychBusters: A means of fostering critical thinking in the introductory course. *Teaching of Psychology, 37(3),* 178-182. doi:10.1080/00986283.2010.488540

Bloom, B. S. (1956). *Taxonomy of educational objectives: The classification of educational goals Handbook 1: The cognitive domain*. New York, NY: David McKay Co, Inc.

Bonwell, C. C., & Eison, J. A. (1991). Active learning: Creating excitement in the classroom. *ASHE-ERIC Higher Education Report No. 1.* Washington, DC: The George Washington University School of Education and Human Development.

Brooks, K. L., & Shepherd, J. M. (1990). The relationship between clinical decision-making skills in nursing and general critical thinking abilities of senior nursing students in four types of nursing programs. *The Journal of Nursing Education*, *29*(9), 391-399.

Browne, M. N., & Keeley, S. M. (1988). Do college students know how to "think critically" when they graduate? *Research Serving Teaching, 1*(9), 2-3.

Burbach, M. E., Matkin, G. S., & Fritz, S. M. (2004). Teaching critical thinking in an introductory leadership course utilizing active learning strategies: A confirmatory study. *College Student Journal*, *38*(3), 482.

Butler, H. A. (2012). Halpern Critical Thinking Assessment predicts real-world outcomes of critical thinking. *Applied Cognitive Psychology, 26*, 721-729. doi:10.1002/acp.2851

Chermack, T. J. (2004). Improving decision-making with scenario planning. *Futures*, *36*(3), 295-309. doi:10.1016/S0016-3287(03)00156-3

Christophel, D. M. (1990). The relationships among teacher immediacy behaviors, student motivation, and learning. *Communication Education*, *39*(4), 323-340. doi:10.1080/03634529009378813

Cohen, M. S., Freeman, J. T., & Thompson, B. (1998). Critical thinking skills in tactical decision making: A model and a training strategy. *American Psychological Association, 23*, 155-189. doi:10.1037/10278-006

Cohn, D., Atlas, L., & Ladner, R. (1994). Improving generalization with active learning. *Machine Learning, 15*(2), 201-221. doi:10.1007/BF00993277

Dillenbourg, P. (1999). What do you mean by collaborative learning? In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and computational approaches* (pp. 1-19). Oxford: Elsevier.

Dooly, M. (2008). Constructing knowledge together. In M. Dooly (Eds.), *Telecollaborative language learning: A guidebook to moderating intercultural collaboration online* (pp. 21-45). Bern, NY: P. Lang.

D'Zurilla, T. J. & Goldfried M. R. (1971). Problem solving and behavior modification. *Journal of Abnormal Psychology, 78*, 107-126.

Ebert-May, D., Brewer, C., & Allred, S. (1997). Innovation in large lectures: Teaching for active learning. *Bioscience*, *47*(5), 601-607. doi: 10.2307/1313166

Ennis, R. H. (1993). Critical thinking assessment. *Theory Into Practice, 32*(3), 179-186. doi:10.1080/00405849309543594

Facione, P. A. (1998). *Critical thinking: What it is and why it counts*. Millbrae, CA: California Academic Press.

Fisher, A. and Scriven, M. (1997). Critical thinking. Its definition and assessment. *Argumentation, 16*(2), 247-251. doi:10.1023/A:1015597228975.

Garrison, D. R., Anderson, T., & Archer, W. (1999). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education*, *2*(2), 87-105. doi:10.1016/S1096-7516(00)00016-6

Glaser, E. (1941). *An experiment in the development of critical thinking*. New York: Teachers College, Columbia University.
Gokhale, A. A. (1995). Collaborative learning enhances critical thinking. *Journal of Technology Education, 7*(1), 1-9.

Gold, J., Holman, D., & Thorpe, R. (2002). The role of argument analysis and story telling in facilitating critical thinking. *Management Learning, 33*(3), 371-388. doi: 10.1177/1350507602333005

Dörnyei, Z. (1994). Motivation and motivating in the foreign language classroom. *The Modern Language Journal, 78*(3), 273-284.

Halpern, D. F. (1998). Teaching critical thinking for transfer across domains: Disposition, skills, structure training, and metacognitive monitoring. *American Psychologist*, *53*(4), 449. doi:10.1037/0003-066X.53.4.449

Halpern, D. F. (2006). Is intelligence critical thinking? Why we need a new definition of intelligence. In P.C. Kyllonen, R.D. Roberts, & L. Stankov (Eds.), *Extending intelligence: Enhancement and new constructs* (pp. 293-312). New York, NY: Routledge.

Halpern, D. F. (2010). Halpern critical thinking assessment manual. *Vienna Test System*, 1-34.

Halpern, D. F., & Nummedal, S. G. (Eds.). (1995). Introduction: Making the case for "psychologists teach critical thinking." *Teaching of Psychology, 22*(1), 4-5.

Halpern, D. F. & Riggio, H. (2003). *Thinking critically about critical thinking* (4 ed.). Mahwah, NJ: Lawrence Erlbaum Associates, Inc. Publishers.

Hendricson, W. D., Andrieu, S. C., Chadwick, D. G., Chmar, J. E., Cole, J. R., George, M. C., ... Kalkwarf, K. L. (2006). Educational strategies associated with development of problem-solving, critical thinking, and self-directed learning. *Journal of Dental Education, 70*(9), 925-936.

Hopson, M. H., Simms, R. L., & Knezek, G. A. (2001). Using a technology-enriched environment to improve higher-order thinking skills. *Journal of Research on Technology in Education*, *34*(2), 109-119. doi:10.1080/15391523.2001.10782338

Johnson, D. W., & Johnson, R. T. (1999). Making cooperative learning work. *Theory Into Practice*, *38*(2), 67-73.

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory Into Practice, 41*(4), 212-218. doi:10.1207/s15430421tip4104_2

Kromann, C. B., Jensen, M. L., & Ringsted, C. (2009). The effect of testing on skill learning. *Medical Education*, *43*(1), 21-27.

Laal, M., & Ghodsi, S. M. (2012). Benefits of collaborative learning. *Procedia-Social and Behavioral Sciences, 31*, 486-490. doi:10.1016/j.sbspro.2011.12.091.

Laal, M., Naseri, A. S., Laal, M., & Khattami-Kermanshahi, Z. (2013). What do we achieve from learning in collaboration? *Procedia-Social and Behavioral Sciences*, *93*, 1427-1432. doi: 10.1016/j.sbspro.2013.10.057

Lawson, T. J. (1999). Assessing psychological critical thinking as a learning outcome for psychology majors. *Teaching of Psychology, 26*(3), 207-209.

Lewis, A., & Smith, D. (1993). Defining higher order thinking. *Theory into Practice*, *32*(3), 131-137.

Linton, D. L., Farmer, J. K., & Peterson, E. (2014). Is peer interaction necessary for optimal active learning? *CBE-Life Sciences Education*, *13*(2), 243-252.

Linton, D. L., Pangle, W. M., Wyatt, K. H., Powell, K. N., & Sherwood, R. E. (2014). Identifying key features of effective active learning: The effects of writing and peer discussion. *CBE-Life Sciences Education*, *13*(3), 469-477. doi: 10.1187/cbe.13-12-0242

Marin, L. M., & Halpern, D. F. (2011). Pedagogy for developing critical thinking in adolescents: Explicit instruction produces greatest gains. *Thinking Skills and Creativity*, *6*(1), 1-13. doi:10.1016/j.tsc.2010.08.002

Mayer, R. E. (1992). *Thinking, problem solving, cognition.* New York, NY: W. H. Freeman.

McDaniel, M. A., Anderson, J. L., Derbish, M. H., & Morrisette, N. (2007). Testing the testing effect in the classroom. *European Journal of Cognitive Psychology*, *19*(4-5), 494-513.

McPeck, J. E. (1990). *Teaching critical thinking: Dialogue and dialectic.* New York, NY: Routledge, Chapman & Hall.

Michaelsen, L., Knight, A., & Fink, L. (Eds.), (2002). *Team-based learning: A transformative use of small groups.* Westport, CT: Praeger.

Miri, B., David, B. C., & Uri, Z. (2007). Purposely teaching for the promotion of higher-order thinking skills: A case of critical thinking. *Research in science education*, *37*(4), 353-369. doi:10.1007/s11165-006-9029-2

Missimer, C. (1986) *Good arguments: An introduction to critical thinking* (2nd ed.). Englewood Cliffs, NJ: Prentice Hall.

Moore, B. N. (1989). *Critical thinking: Evaluating claims and arguments in everyday life* (2nd ed.). Palo Alto, CA: Mayfield.

Morris, S. P. & Ennis, R. H. (1989). *Evaluating critical thinking.* Pacific Grove, CA: Midwest Publications.

Morrison, S., & Free, K. W. (2001). Writing multiple-choice test items that promote and measure critical thinking. *Journal of Nursing Education*, *40*(1), 17-24.

Morrison, S., Smith, P., & Britt, R. (1996). *Critical thinking and test item writing.* Houston, TX: Health Education Systems.

Panitz, T. (1999). Collaborative versus cooperative learning: A comparison of the two concepts which will help us understand the underlying nature of interactive learning. Retrieved from https://files.eric.ed.gov/fulltext/ED448443.pdf

Parmelee, D., Michaelsen, L. K., Cook, S., & Hudes, P. D. (2012). Team-based learning: A practical guide: AMEE guide no. 65. *Medical Teacher, 34*, 275-287. doi: 10.3109/0142159X.2012.651179

Paul, R. (1993). *Critical thinking: How to prepare students for a rapidly changing world.* Santa Rosa, CA: Foundation for Critical Thinking.

Paul, R. and Elder, L. (2008). *The miniature guide to critical thinking: concepts and tools.* Santa Rosa, CA: Foundation for Critical Thinking.

Paul, R., Fisher, A. & Nosich, G. (1993). *Workshop on critical thinking strategies.* Rohnert Park, CA: Sonoma State University. Foundation for Critical Thinking, Sonoma State University.

Penningroth, S. L., Despain, L. H., & Gray, M. J. (2007). A course designed to improve psychological critical thinking. *Teaching of Psychology, 34*(3), 153-157. doi: 10.1080/00986280701498509

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*(3), 223-231. doi:10.1002/j.2168-9830.2004.tb00809.x

Reid, H. (2000). *The correlation between a general critical thinking skills test and a discipline specific critical thinking test for associate degree nursing students (Doctoral dissertation).* University of North Texas Digital Library.

Resnick, L. B. (1987). *Education and learning to think.* Washington, DC: National Academies Press.

Roberts, T. S. (2004). *Online collaborative learning: Theory and practice.* Hershey, PA: Information Science Publishing.

Schweiger, D. M., Sandberg, W. R., & Ragan, J. W. (1986). Group approaches for improving strategic decision making: A comparative analysis of dialectical inquiry, devil's advocacy, and consensus. *Academy of Management Journal*, *29*(1), 51-71.

Scouller, K. (1998). The influence of assessment method on students' learning approaches: Multiple choice question examination versus assignment essay. *Higher Education*, *35*(4), 453-472.

Scriven, M. (1976). *Reasoning.* New York, NY. McGraw-Hill Book Company.

Shin, K. R. (1998). Critical thinking ability and clinical decision-making skills among senior nursing students in associate and baccalaureate programs in Korea. *Journal of Advanced Nursing, 27*(2), 414-418. doi:10.1046/j.1365-2648.1998.00499.x

Sokoloff, D. R., & Thornton, R. K. (1997). Using interactive lecture demonstrations to create an active learning environment. *The Physics Teacher, 35(6),* 340-347. doi: 10.1119/1.2344715

Stein, B., Haynes, A., Redding, M., Ennis, T., & Cecil, M. (2007). Assessing critical thinking in STEM and beyond. In M. Iskinder (ed.), *Innovations in e-learning, instruction technology, assessment, and engineering education* (pp. 79-82). Dordrecht, The Netherlands: Springer.

Thomas, A., & Thorne, G. (2009). *How to increase higher order thinking.* Metarie, LA: Center for Development and Learning.

Toulmin, S., Ricke, R., & Jarki, A. (1984). *An introduction to reasoning* (2nd ed.). New York: Macmillan.

Tractenberg, R. E., Gushta, M. M., Mulroney, S. E., & Weissinger, P. A. (2012). Advances in health sciences education. *Theory and Practice, 17*(5). doi:10.1007/s10459-012-9434-4.

Van Bruggen, G. H., Smidts, A., & Wierenga, B. (1998). Improving decision making by means of a marketing decision support system. *Management Science*, *44*(5), 645-658. doi:10.1287/mnsc.44.5.645

Walker, S. E. (2003). Active learning strategies to promote critical thinking. *Journal of Athletic Training, 38*(3), 263-267.

Welch, M. (1998). Collaboration: Staying on the bandwagon. *Journal of Teacher Education, 49*(1), 26–38. doi:10.1177/0022487198049001004

Youngblood, N., & Beitz, J. M. (2001). Developing critical thinking with active learning strategies. *Nurse Educator*, *26*(1), 39-42.

Zohar, A., & Dori, Y. J. (2003). Higher order thinking skills and low-achieving students: Are they mutually exclusive? *The Journal of the Learning Sciences*, *12*(2), 145-181.

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.

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 three 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 that the bolded 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.