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Me, Myself, and I: The Impact of Metacognitive Strategies on Student Locus of Control and Critical Thinking Skills

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ME, MYSELF, AND I: THE IMPACT OF METACOGNITIVE STRATEGIES ON STUDENT LOCUS OF CONTROL AND CRITICAL THINKING SKILLS

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by

Danielle E. Kuchler

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ABSTRACT

ME, MYSELF, AND I: THE IMPACT OF METACOGNITIVE STRATEGIES ON STUDENT LOCUS OF CONTROL AND CRITICAL THINKING SKILLS

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We live in an era when a college degree is essentially required for entry into good-paying careers, and yet achievement of a college degree is unacceptably low. Only 60% of students who enroll go on to graduate from 4-year colleges and universities in 6 years or fewer (National Center for Higher Education 2018). Why is this happening? What are the long-term intellectual and economic implications of ill-prepared students? We must ask ourselves if students are really prepared with the knowledge, skills, and dispositions to be successful in college and whether those attributes are developed while in college. Two of the skills and dispositions successful university students possess are critical thinking skills (Giancarlo and Facione 2001) and an internal locus of control (Findley and Cooper 1983), outcomes that appear to be facilitated by metacognitive techniques (Arslan and Akin 2014, Magno 2010). This study strived to determine if increasing metacognitive practices in an undergraduate nonmajors biology class would shift students' academic locus of control and critical thinking skills within an academic quarter. Study subjects were Fundamentals of Biology students enrolled at Central

Washington University. A quasi-experimental study design was used to compare two groups of students; one group that experienced increased metacognitive questioning in lab handouts and one group that was taught using standard lab handouts. Group participants each completed an Academic Locus of Control Scale (Curtis and Trice 2013) and California Critical Thinking Skills Test (Faicone 1990) at the beginning and end of a 10-week quarter to determine gains. Through the results of this study, we determined that the metacognitive intervention did not cause significant critical thinking gains nor a shift in academic locus of control. Over 60% of the non-metacognitive lab worksheet questions in this course did not prompt students to think critically. Our future suggestion is to increase the proportion of critical thinking questions in courses to facilitate university-level academic success.

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CHAPTER I

INTRODUCTION

Are Students Prepared for College?

At all levels, educators constantly strive to create a learning environment that teaches students the essential knowledge, skills, and dispositions needed for their lives, college readiness, and future careers (American Association for the Advancement of Science 2011). For American undergraduate students, the persistent lack of college readiness affects their academic, personal, and professional potential in all areas (ACT 2018). Although many factors can contribute to this phenomenon, the fact remains that many students enter college woefully unprepared with requisite knowledge, skills, and dispositions needed to succeed in this rigorous academic environment.

Despite record college enrollment increases across much of the United States, the gap between those who are, and are not, prepared continues to grow. From 2000 to 2016, enrollment in U.S. undergraduate institutions increased by 28%, or about 3.7 million students (National Center for Higher Education 2018a). However, just 60% of students who enroll go on to graduate from 4-year colleges and universities in 6 years or fewer (National Center for Higher Education 2018b). Considering large discrepancies between enrollment and graduation completion, and lost opportunity and real financial costs associated with this gap, one has to wonder: are students truly prepared for college?

The obvious answer to that question is no. And while one might be tempted to accept the loss as modern-day reality, the fact remains that there are additional costs that affect everyone in a democratic society. While there may be increases in college *eligible* students, that does not necessarily mean that students are college *ready* (Conley, 2008). Being college ready does not just mean that students have the academic knowledge expected for the college-level work; it also involves possessing the skills and dispositions that prepare students to deeply learn academic material and to be successful in their courses. Some might say the “simple” solution is to reform the high school experience to ensure students are taught everything they need to know to be successful in college before they enroll. The fact of the matter is that regardless of what is done in high schools, inherent differences in the backgrounds of university students will still exist.

Since students will always come from diverse backgrounds, it may be that the role of undergraduate institutions is to structure courses in ways that help *all* students succeed. The Association of American Colleges & Universities’ Inclusive Excellence Commission specifies a “renewed call for change in undergraduate science education” (2018). In order to create an environment where students strive for excellence, science education in undergraduate institutions must be, “dynamic and both critical of and responsive to surrounding contexts” (Association of American Colleges & Universities 2018). This means that teaching methods and styles must continually change to meet actual student needs and improve the learning experience for students enrolled in university courses. Currently, there is an immense need for students to develop the skills and dispositions needed for success in higher education, the workforce, and as citizens in a democratic society.

CHAPTER II

LITERATURE REVIEW

What Leads to Student Success?

According to graduation rate statistics, it is obvious that not all students are prepared for college, but some certainly are. We must ask ourselves: what leads to student success? Two important factors, which will be the focus of this study, include students' ability to take personal responsibility for their learning and their ability to think critically. Generally speaking, the amount of responsibility individuals feel they have over their life outcomes is called locus of control (Rotter 1966). *Academic* locus of control is the term used when this concept is applied to an intellectual setting (Trice 1985). In short, academic locus of control is the level of personal responsibility students attribute to their academic success. Critical thinking skills also play heavily in student success before, during, and after college (Giancarlo and Facione 2001, Carnevale and Smith 2013). Critical thinking is a skill that involves using cognitive processes in order to solve a problem (Halpern 1999). These two factors are crucial to student academic success, but they are not the only skills and dispositions successful students possess.

Reviews of the literature show many other factors can affect academic success in college. Intrinsic motivation to learn, or taking an interest in what is being taught, is one component. Students who are generally more intrinsically motivated are more engaged and get the most out of their learning experiences (Froiland et al. 2010). Intrinsic motivation is a part of a greater concept called Self-Determination Theory, which states that competence, relatedness, and autonomy can lead someone to be intrinsically motivated (Ryan and Deci 2000). If all three of these elements coalesce in an individual, they are more likely to be motivated to complete tasks.

Another contributor to student success is a growth mindset, which is the idea that the brain is malleable and intelligence is not a static, unalterable trait (Yeager et al. 2016). A study of over 12,000 ninth-grade students determined that a straightforward hour-long student training on growth mindsets can contribute to students' decisions to enroll in higher level math classes compared to peers that did not have this intervention (Yeager et al. 2019). This is noteworthy because high school math achievement is linked to college graduation rate (Adelman 2006). Those who complete advanced high-school math classes are more likely to graduate with a bachelor's degree than peers who do not take advanced math courses (Adelman 2006). Growth mindset interventions have also been shown to positively impact students who are at risk of dropping out (Paunesku et al. 2015). It should be noted that increased academic success via growth mindset intervention was witnessed only in schools where the climate supported the intervention, as demonstrated by peers who embraced intellectual challenges (Yeager et al. 2019).

A close relationship between intrinsic motivation, growth mindset, and other factors on critical thinking appears to exist, but requires further exploration to clarify their relatedness. Here's what is currently known from the literature: a study on 5^{th} and 10^{th} grade students observed that locus of control (referred to as "intellectual achievement responsibility") significantly contributed to student motivation (Tzuriel and Haywood 1985). In the workplace, having an internal locus of control correlated with higher work motivation (Kamdron 2015). Much like locus of control is related to motivation, critical thinking is related to growth mindset. Many of the dispositional traits required to be a critical thinker align with those of someone who has a growth mindset. Faicone and colleagues (1995) stated that there are 7 dispositions required to be critical thinker, including truth-seeking, open-mindedness, analyticity, systematicity, confidence, inquisitiveness, and cognitive maturity. Being open-minded, having confidence, and placing inquisitiveness over the desire to always be correct are all important components of a growth mindset. Overall, there appears to be significant overlap between the various factors that contribute to student success. Further exploration is required in order to clarify these relationships.

Taking Responsibility for Learning

The trait that determines how much personal responsibility a student places on their academic success is academic locus of control, which exists on a spectrum but can be divided into two main categories: internal and external (Rotter 1966). Generally, internals perceive that their own decisions drive their academic success, or lack thereof. On the other hand, externals perceive factors out of their control determine outcomes and academic success (Findley and Cooper 1983). Locus of control and academic achievement appear to be positively correlated; meaning internals tend to have higher academic performance as measured by standardized achievement tests and GPA (Findley and Cooper 1983, Albert and Dahling 2016, Gifford et al. 2006). The learning performance of students in higher education with an internal locus of control are seen to be higher than their external peers (Özen Kutanis et al. 2011). Research has also shown that those who cultivate an internal locus of control experience greater overall well-being in their lives because feeling in control is an indicator of greater self-worth (Ng et al.

2006). Although this research has mostly been conducted in the U.S. and other western countries, an international study in 2001 compared the relationship between locus of control and workplace wellbeing, itself defined as job satisfaction, the absence of psychological markers of stress, and absence of physiological markers of stress (Spector et al. 2001). Researchers discovered that, across 24 nations, countries with greater average internal locus of control also reported higher average workplace wellbeing (Spector et al. 2001).

Much of the research on locus of control has been confined to the time period when it was first being conceptualized; the late 60s to early 80s (Galvin et al. 2018). Although a resurgence in this field of study has occurred, most recent locus of control studies do not explore factors that can *change* individuals' locus of control. Many of these studies are also limited to fields such as health care, psychiatry, and psychology (Ali and Lindström 2008, Harrow et al. 2009, Judge et al. 2002). Recently, researchers have focused on locus of control in an attempt to understand and design more productive work environments (Wang et al. 2010, Ng et al. 2006). Although studies that investigate locus of control as a predictor variable for academic success exist (Findley and Cooper 1983, Gifford et al., 2006), the literature thoroughly lacks research about if and how academic locus of control changes can take place. Therefore, it is essential that we understand locus of control at a more fundamental level through studies that investigate if it is a mindset that can be *altered* in students as well as how it affects other educational outcomes, including critical thinking.

Why Think Critically?

In recent years, critical thinking has been somewhat of a "buzzword" in the field of education research. This is due to the tremendous benefits of being able to think critically. In general, critical thinking is defined as the use of cognitive skills or strategies that lead one to reach a goal, such as successfully solving a problem (Halpern 1999). Some skills are essential to the ability to think critically. People often refer to these as "higher-order thinking skills". Being able to apply concepts, analyze material, evaluate information, and synthesize new ideas from existing knowledge are core to the concept (Adams, 2015). Critical thinking differs from "non-critical thinking" in that it is intentional and evaluative, leading to well thought-out decisions. It differs from other forms of thinking like habitual thinking (where new information is not considered), brainstorming (where no evaluation takes place; just the first thoughts that come to mind), or emotive thinking (where a decision based on emotion, rather than just content) (Huitt 1998). Knowing *when* to apply each form of thinking is a display of critical thinking in itself.

One might wonder how the specific skills that researchers consider to be critical thinking skills are defined. A widely accepted answer lies in Bloom's Taxonomy (Figure 1). Bloom's Taxonomy is a tool used to categorize and prioritize lower-order conceptualization and higher-order critical thinking skills (Bloom 1956). More specifically, the critical thinking skills "apply", "analyze", "evaluate", and "create/synthesize" are considered to be higher-order. The "remember" and "understand" levels of Bloom's Taxonomy are considered to be lower-order thinking and serve as a prerequisite for higher-order critical thinking cognition. Bloom's Taxonomy is considered the de facto standard for assessment of critical thinking in academia (Bissell and Lemons 2006).

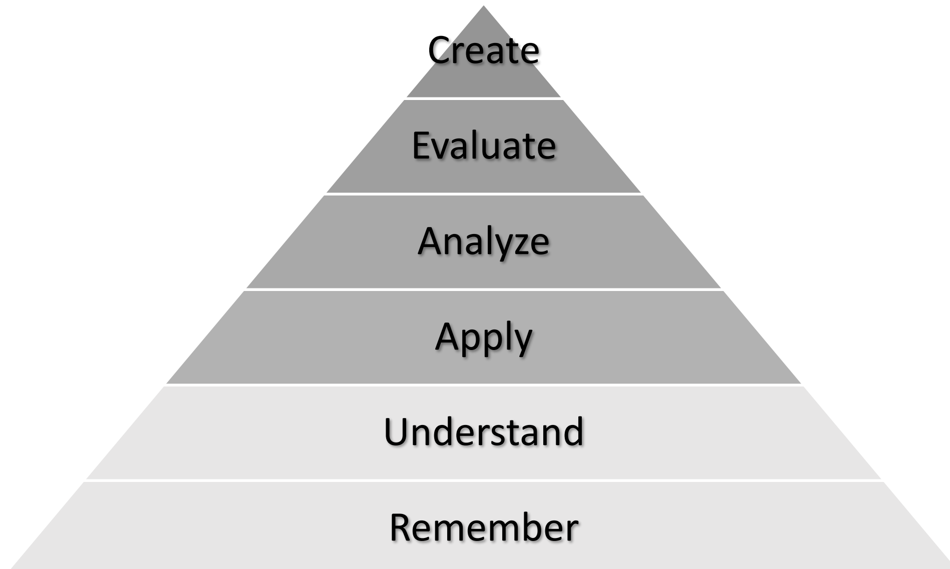

Figure 1. Bloom's Taxonomy, a hierarchical approach to describing different levels of thinking skills. Light gray denotes lower-order thinking skills. Dark-gray denotes higher-order or *critical* thinking skills. Adapted from Bloom, 1956.

The benefits of critical thinking skills on individual academic, personal, and professional lives are well established. Critical thinking skills are correlated with various measures of academic success including GPA (Giancarlo and Facione 2001). In their personal lives, individuals with higher critical thinking skill make improved daily decisions and contribute more meaningfully to a democratic society (Smith and Szymanski 2013). In the professional world, employers preferentially hire individuals who possess critical thinking skill because they tend to perform better in their jobs (Association of American Colleges and Universities 2013). The improved problem-solving and communication skills that come with being an effective critical thinker are partly responsible for better job performance (Carnevale and Smith 2013). Despite its importance, critical thinking is not taught as routinely as it should be in college. In a survey conducted by the Society for Human Resource management, 26% of college graduates lack critical thinking skills (SHRM 2015). Clearly, finding ways to foster student critical thinking skill development will benefit students, both in college and beyond.

Multiple studies have determined that critical thinking is a skill and mindset capable of improvement. For example, when essay writing was incorporated into a general education biology course to replace traditional quizzes, students were observed to have significant gains in their critical thinking skill levels in a period of under 10 weeks (Quitadamo and Kurtz 2017). In addition, Bensley and Spero (2014) found that students who were given an intervention that taught rules for argument analysis, were provided opportunities to read text in a critical manner, and were given detailed feedback, had significant critical thinking gains within 10 weeks. These studies provide evidence that substantial gains in critical thinking skill can occur rapidly among students. Discovering more methods to promote critical thinking skill gains could help students drastically improve their critical thinking.

*How Can **We** Improve Student Success?*

Helping students transition from an external to an internal academic locus of control and improve their critical thinking skills has the potential to improve student learning in undergraduate biology courses. The question then becomes: how can we accomplish these changes? A comprehensive review of the empirical literature on locus of control and critical thinking showed one academic strategy stood out from the rest —

metacognition. Livingston (2003) perhaps best defines metacognition as, “higher order thinking which involves active control over the cognitive processes engaged in learning.” Metacognition includes three overarching components (examples found in Table 3):

1) planning before starting a task,
2) monitoring comprehension while completing the task, and
3) evaluating the thought processes that occurred during the task once its complete (Livingston 2003).

Metacognition was the intervention chosen to help improve students’ internal academic locus of control and critical thinking skills because it is positively correlated with both factors. A study conducted by Arslan and Akin (2014) with a sample group of 451 university students showed a correlation between students who were more metacognitively aware and students who had a more internal locus of control. Another study of 240 freshman university students showed that higher use of metacognitive skills correlated with higher critical thinking skills levels (Magno 2010). Medina et. al (2017), stated, “At its core, a critical thinker is one in charge of their thinking processes, while metacognitive strategies enable such control to take place”; this illustrates the significance of the relationship between critical thinking and metacognition.

In addition to correlation with an internal locus of control and higher critical thinking skills, metacognition is an important strategy to implement in undergraduate biology courses because it helps students continuously reflect and revise thought patterns, processes that all biologists must use as they navigate advanced scientific content (Tanner 2012). Metacognition teaches students how to integrate a variety of complex thoughts and analyze information across content domains (American Association for the

Advancement of Science 2011). Fortunately, incorporating metacognitive techniques and strategies into existing curriculum is fairly straightforward but still has the potential to enable huge improvements in student success. For example, assignments and projects can be adapted to build metacognitive strategies by adding questions that require students to *plan* out their project or assignments, questions that have them *monitor* their learning when completing the assignment, and questions that have them e*valuate* the learning experience (Tanner 2012).

Research Question

This study will explore the effects of metacognitive strategies on academic locus of control and critical thinking skills in an undergraduate nonmajors biology course. The focal question of the study is: Can increased use of metacognitive strategies shift student's academic locus of control and critical thinking skills within an academic quarter?

Hypothesis

Increasing exposure to metacognitive questions will affect academic locus of control and critical thinking skills of undergraduate biology students.

Prediction

If undergraduate biology students are exposed to more metacognitive strategies over the course of an academic quarter, academic locus of control will shift towards internal and critical thinking skills will increase.

CHAPTER III

METHODS

Context

This study took place at Central Washington University, a comprehensive state college located in the city of Ellensburg, WA. During the 2018-19 school year, 12,342 students, primarily from Washington State, were enrolled at Central Washington University. 53% of students enrolled were females, 47% were males, and 35% were students of color (Central Washington University 2019). Seven sections of a nonmajor Fundamentals of Biology lab taught Fall Quarter 2019 were included in the study (n = 89). All students in the course were enrolled in a lecture course that met Tuesday through Friday for 50 minutes for a duration of 10 weeks. Their lab course met every Monday for 2 hours. The lecture course was taught with the same curriculum as previous quarters. The laboratory course was divided into four treatment sections (n = 55) and three control sections (n = 34). There were 130 students enrolled in the course, but only those that took the critical thinking pre and posttest were included in statistical analyses.

Each laboratory section met in the same two lab rooms each week with the exception of week 9 of the course, when all students completed their lab in the university greenhouse. The same instructor taught both sections of lecture and all 7 sections of lab. A graduate student teaching assistant led and consistently taught the same lab section, with the same students enrolled each week.

Control groups and treatment groups differed by the lab assignments they received. Much of the instruction from teaching assistants and professor remained consistent for each group. The control group experienced the same lab assignment format as students previously enrolled in Fundamentals of Biology courses. The treatment groups similarly received lab assignments that asked identical questions as the control group, but with added metacognitive questions as well. Both groups received equal access to materials and instructional support.

A quasi-experimental design was used for this study due to the inability to randomly assign students into treatment and comparison groups. Instead, participants were sorted into their lab sections based on based on enrollment that suited their academic schedules. Demographics between control and treatment groups were compared to determine their similarity (Table 1 and 2). Students provided informed consent prior to taking the California Critical Thinking Skills Test, Academic Locus of Control Scale, and demographics survey. Procedures for this study were in compliance with Human Subjects Review Council’s Institutional Review Board requirements (2019-044-ONC).

Metacognitive Framework

Metacognitive strategies were increased for the treatment group with the intention to increase metacognitive awareness for these students. The comparison group received standard instruction that was not manipulated from curriculum used in past quarters. Consistent with research literature, three main elements were integrated into treatment group labs in order to increase metacognitive strategies: a plan, monitor, and evaluate stage (Tanner 2012). In an educational setting, metacognitive elements can be employed at any time, including during a lesson, during homework assignments, even during an exam (Tanner 2012). There are many effective questions that can be asked of students to prompt metacognitive thinking. In this study, metacognitive questions were added to lab

Table 1. Participant age and gender demographics.

		Age (%)						Gender (%)		
Sample	No.	<18	18-19	20-21	22-23	24-25	26+	Male	Female	Other*
Treatment	55	5.5	45.5	34.5	5.5	3.6	5.5	47.3	49.1	3.6
Control	34	5.9	70.6	17.6	5.9	0	0	50	50	0

*Other includes those who chose not to disclose

Table 2. Participant ethnicity demographics.

		Ethnicity (%)				
Sample	No.	White, Caucasian	Asian, Asian American, Pacific Islander	Hispanic, Latino, Mexican American	Black, African American	Other*
Treatment	55	58.2	21.8	12.7	5.5	1.8
Control	34	73.5	11.8	5.9	2.9	2.9

*Other includes those who chose not to disclose *worksheet* assignments for treatment group participants. Questions were added directly to the worksheets to reduce social interaction variability between students in each experimental group and the course instructor, teaching assistants, and PI. Similar studies that modified undergraduate science courses to build metacognition also integrated questions that prompted students to think about their learning directly into worksheets and assignments (Connell et al. 2015).

Supplemental metacognitive questions were adapted from Tanner's (2012) "Promoting Student Metacognition" and Medina et al.'s (2017) "Strategies for Improving Learner Metacognition in Health Professional Education." Recall that metacognition can be divided into three parts: plan, monitor, and evaluate. Each lab worksheet started with a question asking students to plan. About halfway through the assignment, students were presented with a question that guided them to monitor their comprehension. At the end of the lab worksheet, students had to evaluate or reflect on the assignment, which helped to understand what learning strategies worked well (Medina et al. 2017). Treatment group metacognitive questions were not graded for credit to prevent grade inflation compared to the control group. Example metacognitive included in Table 3.

Table 3. Sample questions included in the lab worksheets intended to promote metacognitive thinking. Adapted from Tanner (2012) and Medina et al.'s (2017) publications on promoting student metacognition.

Metacognitive Phase	Plan	Monitor	Evaluate
Example Questions	• What do I already know about this topic from lecture? • What are the goals of this lab session? What should you be able to do and know?	• What has been the most challenging part of this lab so far? • What can you do to make it easier for the remainder of the lab?	• What did you find most interesting about this lab assignment? • How do the concepts from this lab relate to what you learned during last week's lab session?

Assessment and Measurement

In order to determine the impacts of non-cognitive factors on this study, students completed a demographics and background factors survey modified from Cornell University's College Student Experiences Questionnaire (Gonyea et al. 2003). The survey was created using Qualtrics software and collected student gender, ethnicity, age, class standing, parents' education level, financial status, and motivations for taking the course. Demographics allowed a more detailed comparison of control and treatment groups to ensure comparability and was used to address limitations of the quasi-experimental research design. All assessments were completed in both the first and last weeks of the academic quarter. Students completed demographics surveys on personal computing devices outside of designated lecture or lab time.

Locus of control changes were measured using "A Revision of the Academic Locus of Control Scale for College Students" (Curtis and Trice 2013). A Qualtrics survey was given during the first and last weeks of the quarter to administer the Academic Locus of Control Scale. This scale is a revision of Trice's (1985) Academic Locus of Control Scale, but redesigned with 21st-century students in mind. It was employed to determine if students who experienced increased metacognitive strategies had the tendency to shift towards a more internal or external locus of control. Scores on the scale range from 0 to 21, with lower scores indicating a more internal academic locus of control and higher scores indicating a more external locus of control. As with the demographics measure of this study, students completed this survey on personal devices outside of designated lecture or lab time.

An online version of the California Critical Thinking Skills Test-Numeracy (CCTST-N) (Facione 1990) was used to measure critical thinking skill gains. This test determines an overall critical thinking score as well as subscale scores for specific skills: interpretation, evaluation, explanation, inference, deduction, induction, and numeracy. Participants received results immediately upon completion of the test. Similar to the Academic Locus of Control Scale, the CCTST-N was deployed during the first and final weeks of the quarter and compared to determine potential critical thinking skill gains. Due to scheduling availability, the pre-test was taken on personal student devices during designated lecture time and the post-test was taken on personal student devices during designated lab time.

Lab Worksheet Analysis

A lab worksheet analysis was used to determine student achievement on each lab and participation in answering metacognitive questions. Each content-based lab worksheet question was ranked for critical thinking level using Bloom's Taxonomy (Figure 1). Rubrics were also designed for every content-based lab worksheet question to analyze student achievement consistently. As a part of the lab worksheet analysis, the proportion of metacognitive questions answered by students in the treatment group, as well as the level of detail included in the metacognitive responses, were collected. One graduate and two undergraduate research assistants were trained, calibrated for consistency, and then assisted the PI to analyze student work each week during Winter Quarter 2020.

Analytical Approach

The statistical software package SPSS version 26 (IBM Corp. 2019) was used to manage variables and run statistical tests on sample data. A paired sample t-test was used to determine significance of critical thinking skills and locus of control changes. A repeated-measures ANCOVA was used to test for significance of the critical thinking skill change, determine the effects of contributing variables, and assess if the covariance was equal among the pre and posttest data.

Only 39 students participated in the pre *and* post academic locus of control test, whereas 98 students participated in a pre *or* post academic locus of control test. No significant change in academic locus of control was detected for the 39 students who participated in the pre and post, $t(38) = 1.026$, $p = .295$. This also aligns with the test-retest reliability that Curtis and Trice detected in their Academic Locus of Control Scale (2013). Over a 5-week period, the reliability to consistently respond to questions on the scale was 0.92 (Curtis and Trice 2013), so it is reasonable that the current study did not witness significant changes in a 10-week period. These data seemed to support the notion that academic locus of control is a personality trait that remained stable over the short 10-week period used for this study. As such, using all pre *or* post academic locus of control data, rather than only those with a pre/post match, was deemed tolerable.

A linear regression test was used to determine correlation between all (pre *or* post) academic locus of control and critical thinking skills national percentile changes. Lastly, independent sample t-tests and ANOVAs were used to compare means among specific variables (gender, ethnicity, and parent education level) within the control and treatment groups.

CHAPTER IV

RESULTS

Demographics

As seen in Tables 1 and 2, the demographic data collected from both the treatment and control groups showed similar distributions. The majority of students in each group were between the ages of 18 and 21. There was a near 50/50 split between males and females in each group. The majority of participants identified as “White, Caucasian” followed in descending order by “Asian, Asian American, Pacific Islander,” “Hispanic, Latino, Mexican American,” “Black, African American,” and “Other.” Other also included those who chose not to disclose this this information.

Identifying a Critical Thinking Outlier

Initially, critical thinking data were not normally distributed (Figure 2). There was a case with a very high critical thinking skills pre/post change score compared to the others. Skewness values, kurtosis values, and a boxplot were obtained to examine this data point (Parke 2013). The standardized values for skewness (0.287 ± 0.274) and kurtosis (1.137 ± 0.541) showed that the distribution positively skewed and peaked to some degree. Case 24 (Figure 3) was identified as an extreme outlier and was removed from the sample. The critical thinking skills pre/post change distribution was then reexamined. Three outliers remained, but fell within the 1.5 multiplier range, deemed to be inaccurate at identifying outliers 50% of the time (Hoaglin and Iglewics 1987). After removing Case 24, the distribution appeared to be approximately normal as indicated by lower skewness (-0.125 ± 0.276) and kurtosis (0.235 ± 0.545). The new distribution data can be seen in Figure 4.

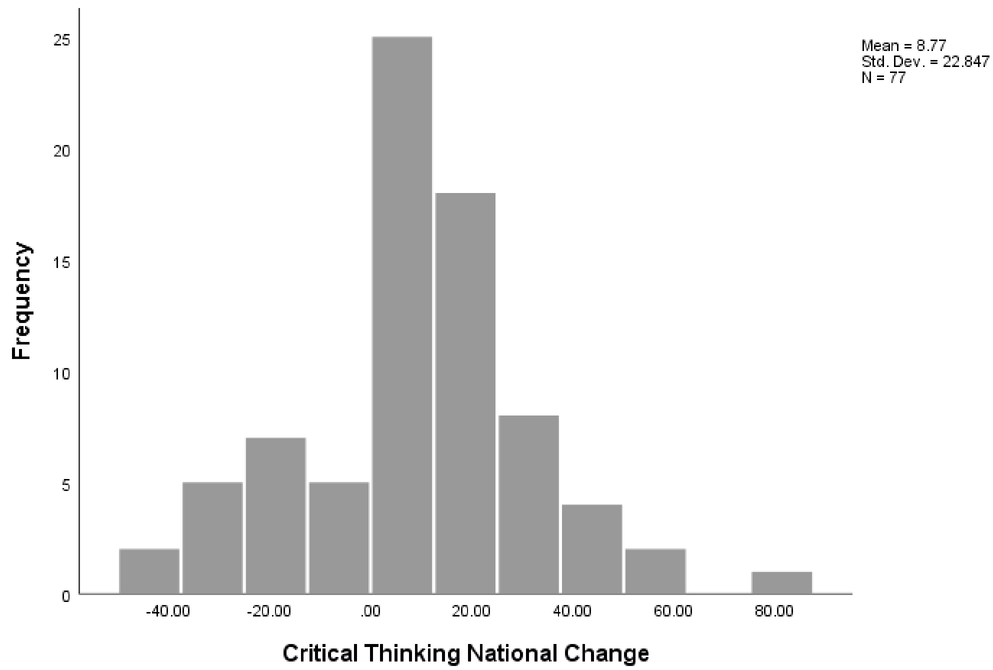

Figure 2. Distribution of critical thinking national percentile changes, prior to removal of outlier.

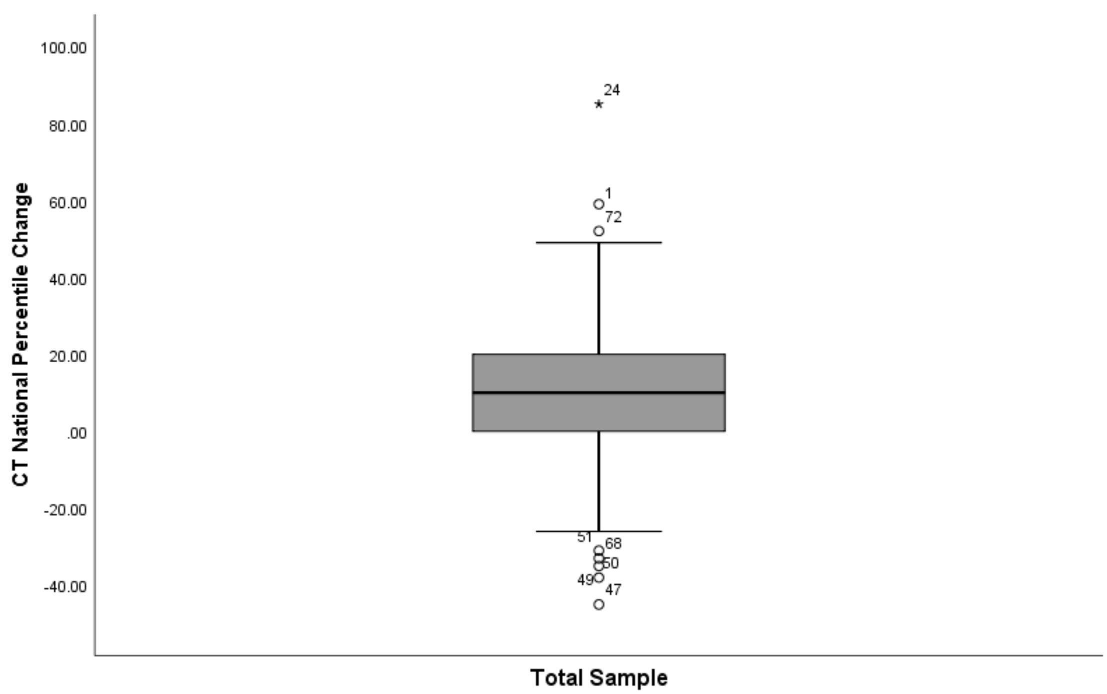

Figure 3. Box and whisker plot showing Case 24 as the extreme outlier for critical thinking national percentile change.

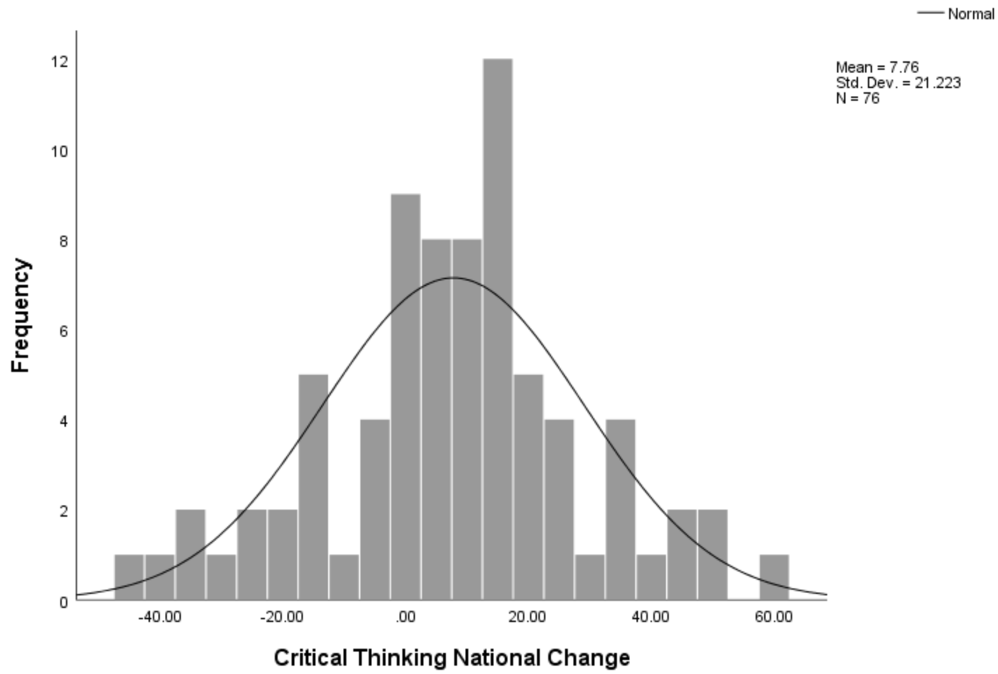

Figure 4. Approximately normal distribution of critical thinking national percentile changes after removal of the extreme outlier.

Effects on Critical Thinking Skills

Table 4 shows the mean pre and post critical thinking test scores, as well as gains for each group. The Box's M value of 1.685 was associated with a p value of 0.652, which was interpreted as non-significant. Thus, the covariance between pre and post tests were assumed to be comparable. There was a slight increase in critical thinking skills national percentile rank for each group. The treatment group increased by an average national percentile rank of 10.04 and the control group by an average of 4.27. After conducting paired sample t-tests of pre and posttests, these results were determined to be statistically significant for the treatment, $t(45) = 3.028$, $p = 0.004$, but not the control group, $t(29) = 1.234$, $p = 0.227$ (Figure 5).

Table 4. Treatment effect on critical thinking changes.						
Group	No.	Pre	SEM	Post	SEM	Raw CT Gain
Treatment	46	29.00	3.12	39.04	3.88	10.04
Control	30	28.10	3.59	32.37	3.96	4.27
Overall	76	28.65	2.34	36.41	2.83	7.76

SEM stands for standard error of the mean. Significance tested at 0.05 level.

Significant critical thinking national percentile gains in the treatment group, as indicated by the t-test, did not include other covariates. To account for this, a repeated-measures ANCOVA was conducted to determine if critical thinking gains among the treatment group remained statistically significant when age, gender, ethnicity, cumulative GPA, parent 1's education, and parent 2's education were controlled for. Instructional method was not found to be significant, $F(1,68) = 0.424$, $p = 0.517$, $\eta p^2 = .006$. ANCOVA results showed that age was the only variable to have a statistically significant effect on critical thinking gains that took place at the 95% confidence interval, $F(1,68) = 3.996$, $p = 0.050$, $\eta p^2 = 0.055$. As age increased, so did critical thinking gains. An initial outlier for age resided over 1.5x outside of the interquartile range, so an ANCOVA was run again, this time excluding the outlier. These final data are shown in Figure 6. Results indicated that age did not have a statistically significant effect on critical thinking gains $F(1,67) = 0.010$, $p = 0.921$, $\eta p^2 = 0.000$. This outlier affected the dataset greatly and transitioned age from a significant to a nonsignificant variable.

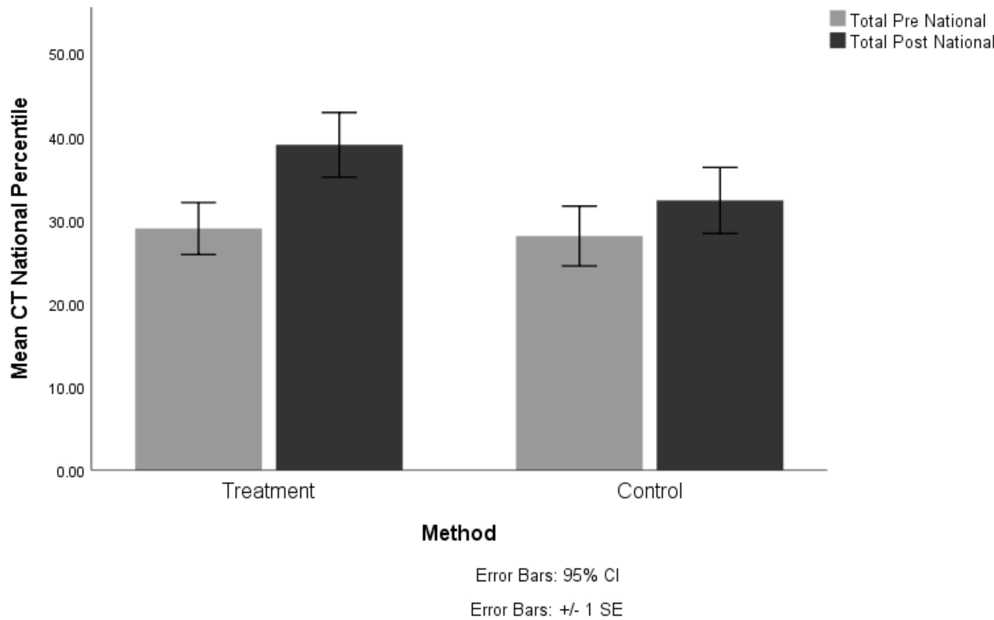

Figure 5. Mean pre and post critical thinking national percentile score for participants in the treatment and control group. T-test results signify a statistically significant difference between average pre and post scores in the treatment group but not in the control group. ANCOVA test results achieved no statistical significance. Error bars are ± 1 SE at the 95% CI.

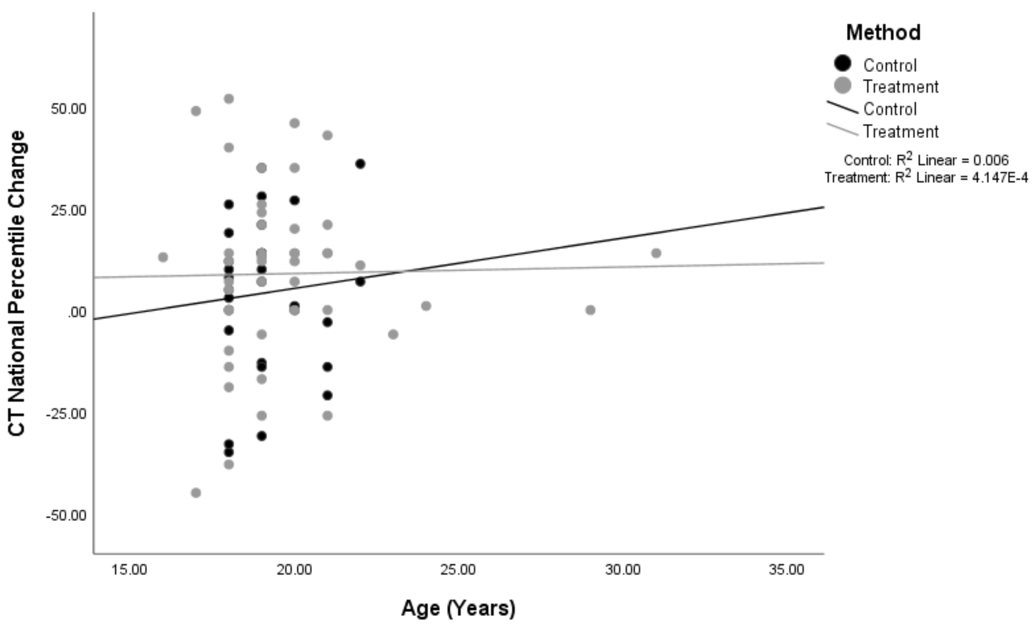

Figure 6. Comparison between age and critical thinking national percentile score change for the treatment and control groups. With the age outlier excluded, this correlation was not found to be significant.

Effects on Academic Locus of Control

Too few participants completed both the academic locus of control pre *and* post (n = 39) as well as the pre and post critical thinking skills test (n = 89) to determine any significant changes in academic locus of control as a function of the intervention. As described in Methods, 98 participants completed a pre *or* post academic locus of control test. Since no significant changes were detected between the academic locus of control for the 39 students who participated in the pre *and* posttest, $t(38) = 1.026$, $p = 0.295$ over a 10-week period, and because locus of control is a stable personality trait, it was determined that using an academic locus of control pre *or* posttest would be acceptable. This interpretation is supported by the test-retest reliability of the original academic locus of control scale, which is 0.92 over a 5-week period (Curtis and Trice 2013).

76 total participants completed either a pre or posttest academic locus of control scale and both a critical thinking pre and posttest. The majority of students (n = 59, 77.6%) included in this final sample scored 10 or below on a scale of 0-21, indicating a predominantly internal academic locus of control. A linear regression was conducted to determine any relationship between academic locus of control and changes in critical thinking skill scores. The regression equation was not found to be statistically significant, $F(1, 74) = 0.013$, $p = 0.910$, with an R^2 coefficient of < 0.001 (Figure 7).

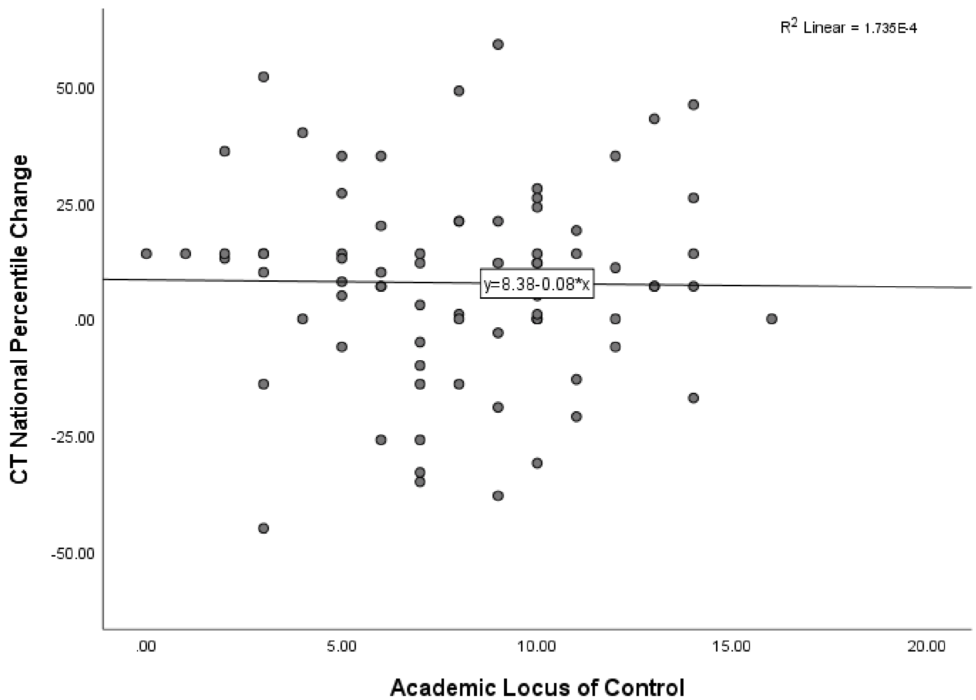

Figure 7. Academic locus of control scores compared to critical thinking change. A linear regression equation indicated no correlation between the two variables.

Effect of Metacognitive Participation on Critical Thinking Gains

During the lab worksheet analysis, it appeared that many students in the treatment group did not complete any or all of the lab assignment metacognitive questions. To determine if completion of the metacognitive questions affected critical thinking gains, completion of metacognitive questions was plotted against critical thinking gains (Figure 8). There was no significant correlation between the percentage of metacognitive questions answered and critical thinking gains, $F(1,53) = 0.004$, $p = 0.947$.

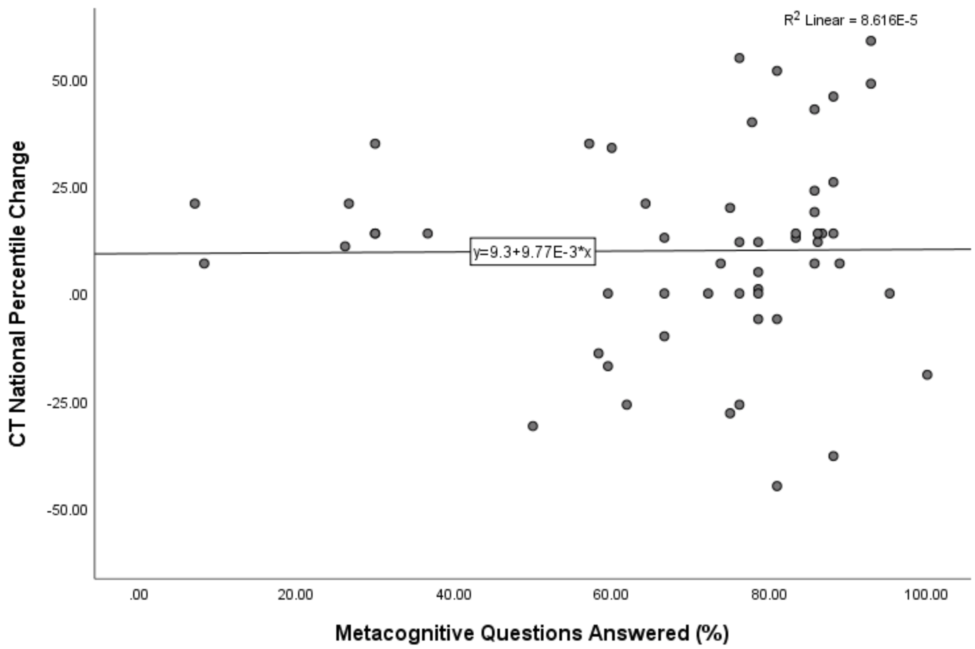

Figure 8. Percent of metacognitive questions answered in the lab worksheets compared to critical thinking change. A linear regression equation indicated no correlation between the two variables.

Bloom's Category Effects on Student Achievement

In addition to the critical thinking and locus of control analysis, student work was analyzed for success on completing questions that had varied critical thinking demands. Each lab handout question was denoted with a "Bloom's Category" tag to indicate cognitive demand, ranked 1-6 (Figure 9). Typically a Bloom's category of 3-6 is considered higher-order, critical thinking. Figure 9 shows that for study participants, student achievement decreased as Bloom's category increased, although the relationship was not significantly correlated, $F(1,96) = 2.872$, $p = 0.093$. For lab worksheet questions, 60% required lower order thinking at the Remember or Understand levels; 40% were considered higher-order critical thinking questions at the Apply, Analyze, Evaluate, and Create levels (Table 5).

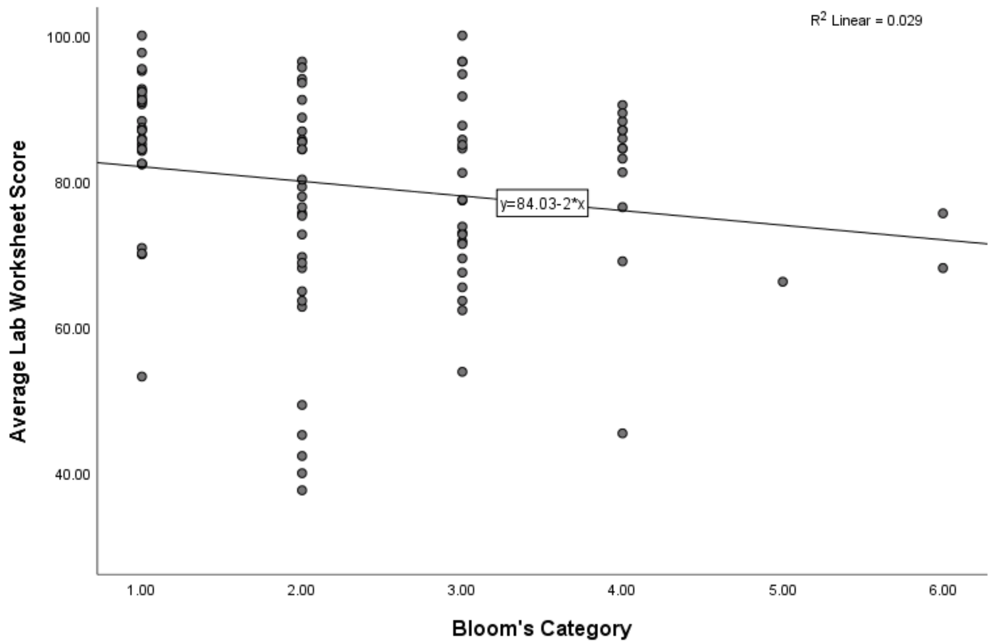

Figure 9. The average score (out of 100) of various lab worksheet questions based on their Bloom's Taxonomy category. 1 = Remember, 2 = Understand, 3 = Apply, 4 = Analyze, 5 = Evaluate, 6 = Create.

Table 5. Number of questions represented in the lab worksheets that test students' ability of each of the following Bloom's Taxonomy categories.

Bloom Category	Remember	Understand	Apply	Analyze	Evaluate	Create	Total
No. Questions	29	30	23	13	1	2	98
% Questions	29.6	30.6	23.5	13.3	1.0	2.0	100

Gains Among Specific Groups

Critical thinking gains within the control and treatment groups were also analyzed for the effects of several covariates, including gender, ethnicity, age, and parents' education level. For gender, only individuals who identified as male or female were examined because too few individuals identified as "other" in both groups to enable comparison (Figure 10). An independent-samples t-test, used to compare average critical thinking national percentile change between females and males, showed no significant difference, for either the treatment group, t(42) = 0.608, p = 0.766, or control group t(28) = -0.990, p = 0.331. Treatment group contained 23 females and 21 males and control group contained 16 females and 14 males.

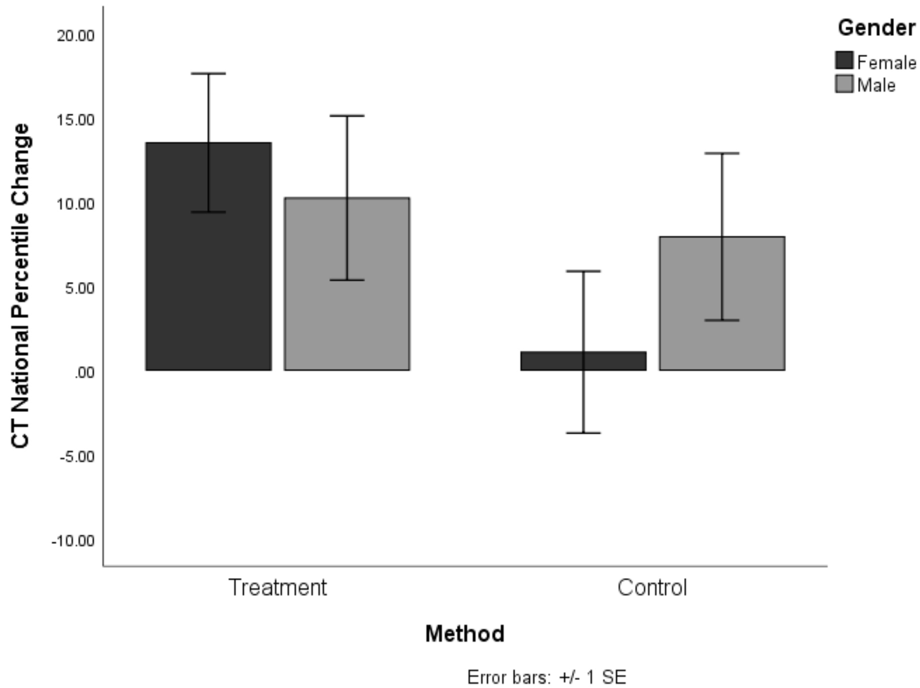

Figure 10. Comparison between critical thinking national percentile gains for females versus males in the control and treatment groups. Error bars are ± 1 SE at the 95% CI.

Ethnicity comparisons between treatment and control groups were difficult to make because not all groups had enough participants to calculate a mean. There were no individuals that disclosed “other” or “I choose not to provide this information” in the treatment group, so those groups were excluded from this analysis. There was only a single case for individuals that disclosed “Black, African American” as their ethnicity in the control group, meaning no mean could be calculated, similarly excluding this group from the analysis. No respondents in either the control or treatment group disclosed they were "American Indian, Native American". A one-way ANOVA used to determine significant critical thinking national percentile differences between ethnicities within the treatment group, $F(2,42) = 0.644$, $p = 0.531$, and control groups, $F(2,26) = 0.176$, $p = 0.839$ showed no statistical significance. Results are graphically represented in Figure 11 The treatment group contained 30 White, 9 Asian, and 4 Hispanic participants. The control group contained 22 White, 3 Asian, and 2 Hispanic participants.

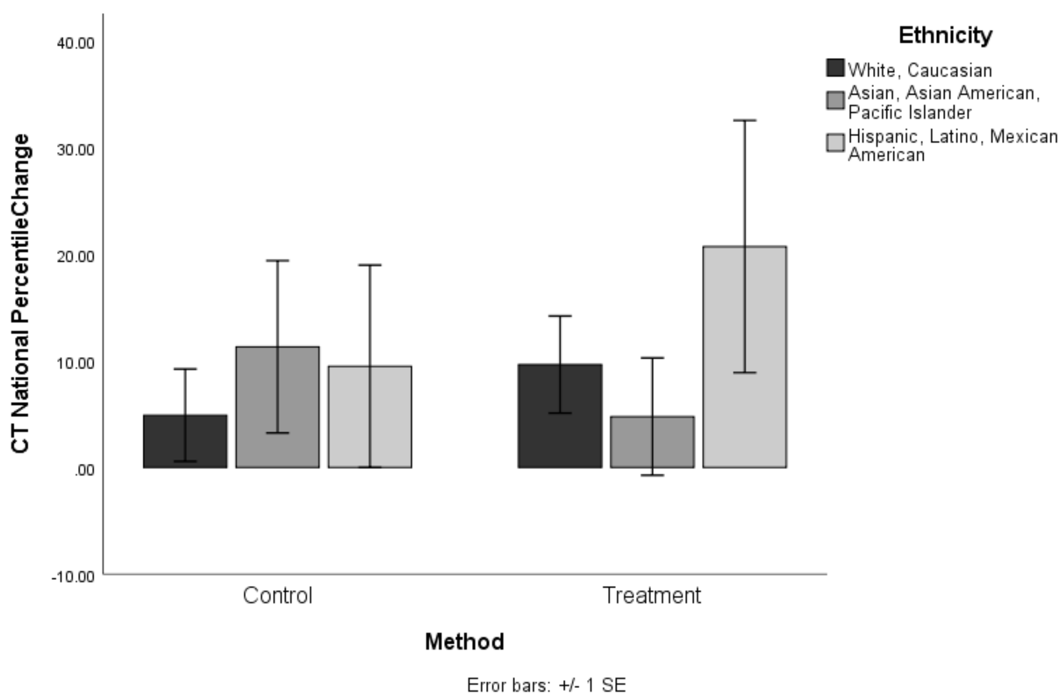

Figure 11. Comparison between critical thinking national percentile gains for the following ethnicities: White, Asian, and Hispanic. There were not enough respondents to calculate comparable means for Black, other, and those that chose not to provide information. Error bars are ± 1 SE at the 95% CI.

For parent 1's education level, "Unknown", "Some High School", and "Doctorate Degree" had to be excluded from analysis because there was only one respondent that chose each of those in the control group, so a mean could not be calculated (Figure 12). A one-way ANOVA was conducted to determine if any significant critical thinking national percentile changes existed between individuals with different parent education levels. There were no statistically significant critical thinking changes between individuals with different parent 1 education levels in the treatment group, $F(3,40) = 1.484$, $p = 0.235$ or control group, $F(3,26) = 1.140$, $p = 0.354$. The treatment group contained 16 students whose parent 1 held a high school diploma, 6 with an associate degree, 10 with a bachelor's degree, and 9 with a master's degree. The control group contained 13 students whose parent 1 held a high school diploma, 4 with an associate degree, 6 with a bachelor's degree, and 4 with a master's degree.

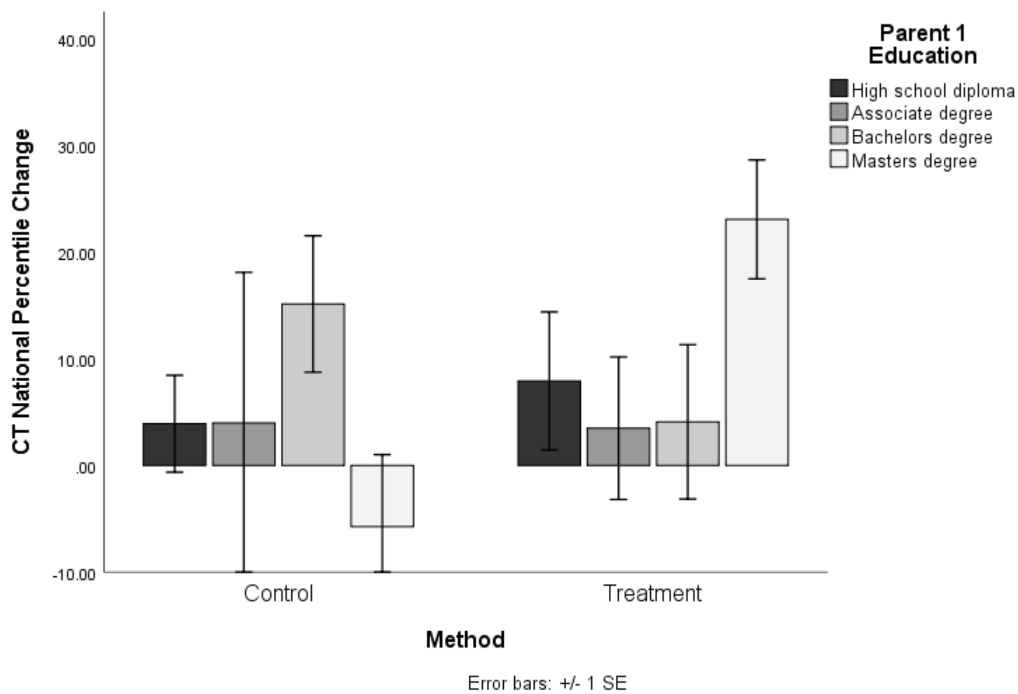

Figure 12. Comparison between critical thinking national percentile gains for parent 1 education levels: high school diploma, associate degree, bachelor's degree, and master's degree. There were not enough respondents to calculate means for unknown, some high school, or doctorate degree. Error bars are ± 1 SE at the 95% CI.

For parent 2's education level, "Some high school" had to be excluded from analysis because no participants in the control group were identified with that response. "Associate degree," "Unknown," and "No second parent or guardian" were also excluded because there was only one respondent for each of those variables in the control group, so a mean could not be calculated. "Doctorate degree" had to be excluded for the same reason. There was only one respondent in the treatment group, so a mean could not be calculated (Figure 13). The results of a one-way ANOVA indicated there was no statistically significant difference between parent 2 education levels in the treatment group, $F(2,29) = 0.982$, $p = 0.388$. The results of a one-way ANOVA showed no statistically significant difference existed between parent 2 education levels in the control group either, $F(2,26) = 0.339$, $p = 0.716$. The treatment group contained 17 students whose parent 2 held a high school diploma, 9 with a bachelor's degree, and 4 with a master's degree. The control group contained 16 students whose parent 2 held a high school diploma, 6 with a bachelor's degree, and 5 with a master's degree.

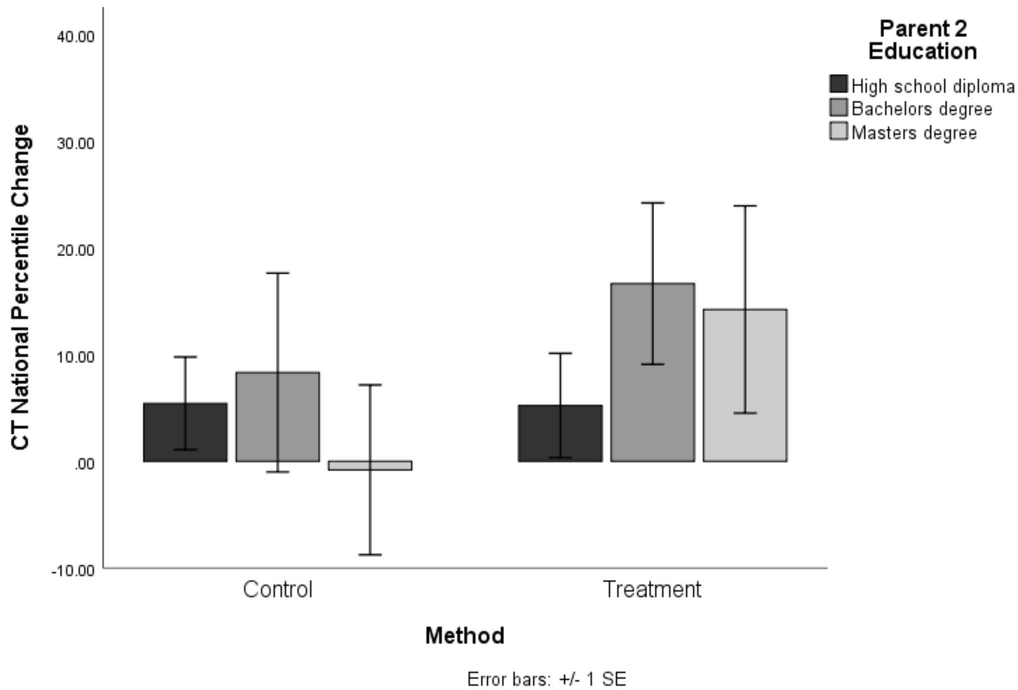

Figure 13. Comparison between critical thinking national percentile gains for parent 2 education levels: high school diploma, bachelor's degree, and master's degree. There were not enough respondents to calculate means for unknown, some high school, or associate degree, or doctorate degree. Error bars are ± 1 SE at the 95% CI.

CHAPTER V

DISCUSSION

This study investigated the effects of metacognitive strategies on undergraduate nonmajor biology student academic locus of control and critical thinking skills. My hypothesis was that students who experience metacognitive questions in lab would shift to a more internal academic locus of control and their critical thinking skills would increase during a 10-week academic term. Results for the effects of academic locus of control on critical thinking performance showed no statistical significance. A smaller than anticipated sample for pre and posttest matched data meant that analyses were limited in their scope. The second part of my hypothesis, which stated that critical thinking skills would increase more for the treatment group than the control group, was not supported by results. A statistically significant change in critical thinking scores did occur for the treatment group during the academic term, but any statistical significance was eliminated when covariates such as age, gender, ethnicity, cumulative GPA, parent 1's education, and parent 2's education were included in the analysis.

Metacognition and Critical Thinking

The inclusion of increased metacognitive strategies in the treatment group did not cause statistically significant critical thinking national percentile gains as compared to the control group. These findings contrast other studies that investigated the relationship between metacognition and critical thinking. For example, Ku and Ho (2010) found that the ability to successfully use metacognitive processes was an important factor in predicting undergraduate critical thinking skill. Magno's 2010 study also reported that higher critical thinking skills were observed in university students that used metacognitive strategies more frequently.

My results likely did not mirror those from the existing literature due to the methods I employed. Scientific study of critical thinking is multidimensional in its nature (Bensley and Murtaugh 2012), and this created perhaps the largest challenge in the research design. For example, proper implementation of metacognitive strategies were key to this study because metacognition was the method hypothesized to facilitate critical thinking gains. In the process of designing the experiment, I decided to embed metacognitive questions that encouraged students to "plan, monitor, and evaluate," within the context of the lab worksheets. This choice was made in an attempt to minimize social interaction threats to internal validity, which Tofthagen (2012) describes as, "social relationships and interactions with others [that] influence the outcome." Unfortunately, my strong focus on minimizing this minute internal threat to the data, led to the metacognitive process not being explicitly and intentionally discussed with students so that they could for successfully practice metacognition.

Multiple studies show that undergraduate students have very low metacognitive awareness, which is the ability to predict academic performance based on the learning strategies employed (McCabe 2011, Karpicke et al. 2009). Through self-reported measures of study habits, researchers found that most college students lack the metacognitive awareness to determine which study habits are most useful and to self-regulate their learning (Karpicke et al. 2009). Since most undergraduate students lack metacognitive awareness, it is essential they learn explicitly *about* metacognition and how to successfully use it when learning. Students need more than just simple exposure to metacognitive questions; they also must know “when, how, and which strategy to use” depending on the academic task to be completed (Ku and Ho 2010).

Educators attempting to increase student metacognition should be aware that two forms of metacognition currently exist: metacognitive *knowledge* and metacognitive *regulation* (De Backer et al. 2012). Metacognitive knowledge refers to what we know about our cognitive processes. This includes understanding the tasks, strategies, and content we excel at versus those where we perform weakly (Perfect and Schwartz 2002, Fernandez-Duque et al. 2000). Essentially, metacognitive knowledge is the level of awareness one has about their thoughts and problem-solving processes. Metacognitive regulation, on the other hand, pertains to the processes used to regulate knowledge (Fernandez-Duque et al. 2000). The overarching method of metacognitive regulation is to “plan, monitor, and evaluate”, processes of which were used in this study (Ku and Ho 2010). Since this study only used the “plan, monitor, and evaluate” strategy, it lacked an essential component to successfully integrate metacognition at the course level. Overall, this study did not include a strong enough metacognitive intervention because it focused solely on metacognitive regulation. Students were not provided with the metacognitive *knowledge* to self-regulate their learning.

Academic Locus of Control

There was too small of an Academic Locus of Control Scale pre/posttest match sample to calculate and compare academic locus of control changes between the control and treatment group. Between the literature indicating the temporal durability and sample analysis showing no change in academic locus of control over 10 weeks, the decision was made to use either the pre or posttest as the indicator. Fortunately, there were enough students who took the pre *or* post academic locus of control scale for it to be compared to critical thinking gains. Most students who completed the self-reported scale were on the internal end of the academic locus of control spectrum. No significant correlation was present between an individual's academic locus of control and their critical thinking skill gains. So according to this study, someone who possesses a more internal academic locus of control is just as likely to have the same critical thinking gains as someone who possesses a more external academic locus of control.

So what do these findings mean? Other studies have found that an external locus of control negatively correlates with critical thinking levels (Bahadir et al. 2014, Oğuz and Sariçam 2016). Bahadir and colleagues (2014) observed that university students with a more external locus of control had lower disposition toward critical thinking than those with a more internal locus of control. It is important to note that critical thinking *dispositions* differ from critical thinking *skills* – a dependent variable measured in this study – but are still closely related. Critical thinking dispositions include, curiosity, open-mindedness, systematicity, analyticity, truth-seeking, self-confidence, and maturity (Facione et al. 1995). A 2016 study by Oğuz and Sariçam witnessed a similar trend to the previous study, which showed that participants with a more external locus of control also had lower critical thinking disposition.

Another issue to consider with the academic locus of control data in this study is its self-reported nature. The Academic Locus of Control Scale is based on self-reported survey data, compared to the California Critical Thinking Skills Test, which is a standardized test based on performance of various question types. Some of the questions on the Academic Locus of Control Scale have the potential to be affected by a factor like social desirability bias, where students prefer to answer questions based on what is considered socially acceptable, rather than what is truthful (Gonyea 2005, Krumpal 2011). For example, when a student is asked if the following statement is true or false, "For some courses it is not important to go to class" (Curtis and Trice 2013), they might respond with "false" even if they think it is true because that is what is socially/academically acceptable.

The way a student interprets a question can even impact their response, as shown in a study on self-reported behavior by Pace and Friedlander (1983). In addition, due to time constraints in the course, the Academic Locus of Control Scale had to be taken on students' own time, outside of class. This was a large contributor to the lack of pre and post academic locus of control data collected. Still, it is important to note that self-reported surveys are one of the few methods that attitudinal data from study participants can be assessed (Gonyea 2005). Despite the potential inaccuracies of self-reported data, it remained the most feasible means to collect academic locus of control data. A recommendation is to ensure data can be collected during proctored assessment times to increase response rate and to verify environmental factors are held constant.

Metacognitive Participation

Since metacognitive questions were embedded directly into lab worksheets but not graded for credit, many students in the treatment group did not complete the metacognitive questions presented. If students did not actively participate in the intervention, how well could the metacognitive treatment be represented in the results?

To answer this question, the number of metacognitive questions each student completed over the course of the academic quarter was plotted against critical thinking change. This helped to understand whether answering metacognitive questions had an effect on critical thinking change. No correlation was observed between these variables. The number of metacognitive questions a student answered had no effect on critical thinking change. This was further evidence that the metacognitive intervention was not intentional enough. Students went through the motions of metacognitive regulation (plan, monitor, and evaluate), but they had no instruction about metacognitive knowledge (what metacognition is, how it is used or how it would benefit them). Since most undergraduate students lack metacognitive awareness (McCabe 2011, Karpicke et al. 2009), it is important to explicitly discuss the process with students in addition to creating the scaffolding necessary to guide them through how to use metacognition.

Bloom's Category and Student Achievement

In general, as questions increased in Bloom's category, student achievement on questions decreased, although this correlation was not statistically significant. Bloom's category is a widely used measure of critical thinking skill level that exists on a scale of 1 to 6: 1 = remember, 2 = understand, 3 = apply, 4 = analyze, 5 = evaluate, 6 = create. Categories 3-6 are considered higher-order, critical thinking. Since higher-order, critical thinking questions require more cognitive demand to answer, the observation that student achievement decreased as Bloom's category increased is not surprising. Many students are not exposed to higher-order thinking questions throughout their educational career; most experience education that has low cognitive demand. This problem is compounded by the flawed logic of some K-12 teachers. Studies indicate many teachers believe that lower-achieving students should not be exposed to higher-order thinking questions because they have not yet mastered low-order concepts (Zohar 2001). This flies in the face of the biological reality, which indicates that human children are hard-wired to think critically and abstractly by around second grade. Unfortunately, this faulty mindset prevents many students from practicing how to think critically in the classroom.

Table 5 illustrates how many fewer higher-order/critical thinking questions there were in the lab worksheets as compared to low-order thinking questions. Low-order thinking questions, which typically require simple memorization, comprised over 60% of the questions included in lab worksheets. The tendency to emphasize lower-order thinking is certainly not unique to the course included in this study. Zheng et al. (2008) analyzed the Bloom's category of nearly 600 questions taken from various sources such as the MCAT, GRE, AP biology tests, introductory biology examinations, and medical school examinations. The study found that in the majority of the contexts examined, the proportion of higher-order thinking questions was lower than that of low-order thinking questions, including medial school exams (21% higher-order), the GRE (35%), AP Biology exam (36%) and the MCAT (45%) (Zheng et al. 2008). This is likely due to the fact that higher-order thinking questions, especially those that use a multiple-choice format, are much more difficult and time-consuming to write than low-order thinking questions. Regardless, if the goal is to promote critical thinking in higher education, low-order thinking questions should ideally make up a much smaller percentage of questions that students are exposed to so that they can get more practice answering higher-order thinking questions.

Gains Among Specific Groups

Four covariables of gender, ethnicity, parent 1's education level, and parent 2's education level were analyzed further to determine if any demographic groups had greater critical thinking gains than others. In both the treatment and control groups, no significant differences were observed between male and female critical thinking gains. Other intervention-based studies have observed critical thinking skill gain differences by sex. For example, when Peer Led-Team Learning (Quitadamo et al. 2009) and Community-based Inquiry (Quitadamo et al. 2008) were used to teach undergraduate science students, females who had experienced lower gains relative to males historically showed greater critical thinking skill gains than males when active learning methods were used. When considering critical thinking disposition, a study investigating the relationship between disposition and sex found that females also tended to have higher overall critical thinking dispositions compared to males (Walsh and Hardy 1999).

Ethnicity appeared to have no statistically significant impact within the control and treatment groups. It should be noted that due to sample size only three groups could be compared: "White, Caucasian," "Asian, Asian American, Pacific Islander," and "Hispanic, Latino, Mexican American". The other groups included in the study, "Black, African American," "American Indian/Native American," "other," and "I choose not to disclose," lacked enough participants to calculate a mean. An early technical report of the California Critical Thinking Skills Test found that although there were no inherent biases for or against any ethnic groups in the test itself, a critical thinking course the author implemented resulted in critical thinking gains for Black and White students, but limited critical thinking gains for Asian or Hispanic students (Faicone 1990b). This demonstrates the importance of analyzing interventions in the context of student demographics. Just because an approach shows improvement for participants *overall* does not mean that every demographic group will benefit. It is important for all science educators to critically examine "practices that have sustained barriers to the inclusion and full engagement of … students and faculty" (Association of American Colleges & Universities 2018). Without constant self-examination of teaching practices, science education will never completely serve the dynamic student populations at our universities.

Neither parent 1 nor parent 2's education level had any statistically significant effect on critical thinking gains among participants in the control or treatment groups. For parent 1, only students whose parent held a high school diploma, associate degree, bachelor's degree, or master's degree could be compared. There was not enough data to calculate a mean for those in the categories of "unknown," "some high school," and "doctorate degree." The same applied to the analysis of parent 2's education, but this time "associate degree" also could not be analyzed due to lack of data. Prior critical thinking studies observed mixed results from the impact of parent education level on critical thinking gains. In some studies, parent education was seen to have no significant effect on critical thinking levels in undergraduate (Quitadamo et al. 2011) and middle school (Gibson 2013) settings. Alternatively, one study of undergraduate, graduate, and doctorate social work students showed that the participants who reported both of their parents held college degrees had significantly higher critical thinking scores than those whose parents did not (Deal and Pittman 2009). These findings would seem to indicate that family culture is an important factor for critical thinking. While this area would be interesting for future research, it is beyond the scope of the current study.

CHAPTER VI

CONCLUSION

Results from this study did not support the hypothesis that increased metacognitive strategies in an undergraduate introductory biology course would shift student academic locus of control towards internality and produce critical thinking skill gains. Lack of student participation in the pre and post Academic Locus of Control Scale led to inconclusive results about academic locus of control change and was thus regarded as a static, rather than altered, trait for the purpose of analysis.

Critical thinking national percentile rank did not significantly change from the beginning to the end of the 10-week quarter for either the treatment or control groups when analyzed in the context of covariates. No significant changes were found when disaggregated by gender, ethnicity, or parents' education levels either. These results were surprising given that prior literature shows that higher use of metacognition is correlated with greater critical thinking skill and disposition levels. The reason for the conflicting results between prior literature and this study may be because of incomplete implementation of the metacognitive intervention in this study.

Considerable evidence indicates that undergraduate students severely lack metacognitive awareness. With no proper guidance as to what metacognition is, what its benefits are, and how it can be used, students cannot be expected to improve their critical thinking. The design of this study included a minor intervention in an attempt to minimize social interaction threat and minimize the amount of time removed from content-based instruction. This study indicates that for metacognitive strategies to truly increase in courses, they must be explicitly taught. In future studies, researchers should still take measures to minimize social interaction threats, but not sacrifice the intensity of the intervention. A strong argument should be made to course instructors of the importance of taking time “away” from content-based instruction to teach metacognition, which, based on research literature, is likely to pay education dividends over time.

Future studies that wish to investigate the impact of metacognition on science student cognitive skill and mindsets such as academic locus of control should use very explicit and intentional interventions designed to increase metacognition within colleges courses. A research supported intervention that may achieve this task is the Blooming Biology Tool, where students in biology courses are instructed about what Bloom’s Taxonomy is, how to rate questions with a Bloom’s category, and how to identify which thinking skills they struggle most with (Crowe et al. 2008). This strategy may help to actively combine metacognitive knowledge and regulation within science courses.

Overall, the results of this study highlight the need for further research about the interactions between metacognition, academic locus of control, critical thinking, and the many other variables undergraduate students bring to classrooms and labs. This study also highlights the need for increased higher-order thinking questions in course material, so students have the opportunity to experience higher cognitive demand and practice these life skills. Lastly, this study emphasizes the immense complexity of research on human learning and the need for clear, well-designed interventions that positively impact the student knowledge, skills, and dispositions that enable academic, personal, and professional success and lead to a more just, democratic society.

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APPENDIX A

Student Demographics Survey

Q1 Please read the following information about this research study and click the "I accept" button at the bottom of your screen if you are interested in participating. You are being asked to participate in a research study of critical thinking. Critical thinking is essential for your academic, personal, and professional success. You have been selected to participate in this study because you are a student and we want to discover the best possible ways to teach for critical thinking. You must be 18 years or older to participate in this survey. This web-based survey will take approximately 5 minutes to complete. By choosing to participate you will help us understand more about how to teach critical thinking and improve student success. Improving student critical thinking will help our country solve the most pressing problems facing society. We believe that all students should receive the highest quality education that is effective, equitable, and free from bias. We know learning to think critically is hard, and we want to help all students be successful by teaching in ways that build these skills. If you submit a survey, the researchers will aggregate your responses and use them to identify trends by group, not by individual. Results will be used for the express purpose of informing teaching practices and how to best meet student learning needs. All individually-identifying information will be removed prior to any analysis.

We hope to gather as many responses as possible to make our results truly representative of current students. Data will be stored on an encrypted secure server and can only be accessed by Dr. Ian Quitadamo and graduate student, Danielle Kuchler. Under no circumstances will any personally-identifiable data be released to the public. Results will be communicated in aggregate form only.

There are no anticipated risks, physical discomforts, or psychological stresses associated with these research procedures. You may withdraw from participating at any time and to do so you simply close your internet browser. Declining to participate will involve no penalty to you. Reasonable and appropriate safeguards have been used in the creation of the web-based survey to maximize the confidentiality and security of your responses; however, when using information technology, it is never possible to guarantee complete privacy. You can ask questions about the research by contacting Dr. Ian Quitadamo, Central Washington University, (509) 963-2745, iq@cwu.edu. You may also contact the CWU Human Protections Administrator if you have questions about your rights as a participant or if you think you have not been treated fairly. The HSRC office number is (509) 963-3115. Please click "I accept" if you are 18 years or older and wish to participate.

○ I ACCEPT. I recognize that by responding to this survey I am providing informed consent and understand that the researchers will take every reasonable measure to protect my anonymity.

○ I DO NOT ACCEPT. I do not provide informed consent for my responses. I do not wish the researchers to include this data in their group results.

Q2 What is the current academic term?

○ Fall 2019

○ Winter 2020

Q3 Which lab section are you enrolled in?

Q4 What is your gender?

- ○ Female
- ○ Male
- ○ Non-binary/third gender
- ○ Prefer to self-describe
- ○ Prefer not to say

Q5 What is your current age?

Q6 I identify my ethnicity as:

- ○ Asian, Asian American, Pacific Islander
- ○ Black, African American
- ○ Hispanic, Latino, Mexican American
- ○ Native American, American Indian
- ○ White, Caucasian
- ○ Other
- ○ I Choose Not to Provide this Information

Q7 What is your class standing?

- Freshman
- Sophomore
- Junior
- Senior
- Postbaccalaureate

Q8 For the person/people who raised you, what is the HIGHEST EDUCATION LEVEL for parent/guardian 1?

- Some high school
- High school diploma
- Associate degree
- Bachelor's degree
- Master's degree
- Doctorate degree
- Unknown

Q9 For the person/people who raised you, what is the HIGHEST EDUCATION LEVEL for parent/guardian 2?

- Some high school
- High school diploma
- Associate degree
- Bachelor's degree

○ Master's degree

○ Doctorate degree

○ Unknown

○ No second parent or guardian

Q13 What is your cumulative GPA range?

○ 0.0-0.5

○ 0.6-1.0

○ 1.1-1.5

○ 1.6-2.0

○ 2.1-2.5

○ 2.6-3.0

○ 3.1-3.5

○ 3.6-4.0

○ GPA not calculated/unknown

Q14 Which field best describes your anticipated major?