ABSTRACT

The Impact of Metacognition Training on Undergraduate Biology Students

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Metacognition can be thought of as how individuals think about and control their own learning. Metacognitive skill has been tied to improved academic performance and thinking skills. In this study, undergraduate biology students received training in three aspects of metacognition: planning, monitoring, and evaluating. The goal of this study was to investigate if students who were explicitly taught metacognitive skills through online instructional videos and quizzes bettered their academic performance and increased metacognitive awareness. Course grades and scores on a metacognitive awareness inventory were compared between groups across one academic semester. The results showed a significant improvement in one skill set, monitoring, and students in the experimental group showed improvements in final laboratory grades in their biology course that closely approached significance. These results indicate that further testing as well as some alteration to the content of the training are warranted.

APRROVED BY DIRECTOR OF HONORS THESIS:

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THE IMPACT OF METACOGNITION TRAINING ON UNDERGRADUATE BIOLOGY STUDENTS

A Thesis Submitted to the Faculty of

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By

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CHAPTER ONE

Introduction

Metacognition is an aspect of learning theory that can be described as how one thinks about his or her own thinking. More specifically, it refers to the one's ability to reflect on, understand, and control learning (Schraw and Dennison 1994). Metacognitive learning involves a series of executive thinking processes that are intimately involved with cognitive control and self-regulation (Colbert et al. 2015).

Metacognition is traditionally thought of as containing three different components, or stages: planning, monitoring, and evaluating (Zepeda et al. 2015). The planning stage involves such things as making sure you understand the problem or task you are faced with, identifying the goal, and strategizing to create a plan that will help you accomplish this goal. The second stage, the monitoring stage, involves continually returning back to the plan that you established earlier to keep track of where you are in the process and if what you are doing is helping you remain on track to accomplishing your goal. Finally, the evaluating stage involves thinking critically about your performance on the task and using these observations to inform your next steps or future approach to similar tasks, as well as assessing if one's finished product accomplishes the goal identified in the planning stage. These stages come together to form a cycle, allowing stages to be repeated or revisited if necessary. A visual depiction of the stages of metacognition as well as some key features of each stage can be found in Figure 1.

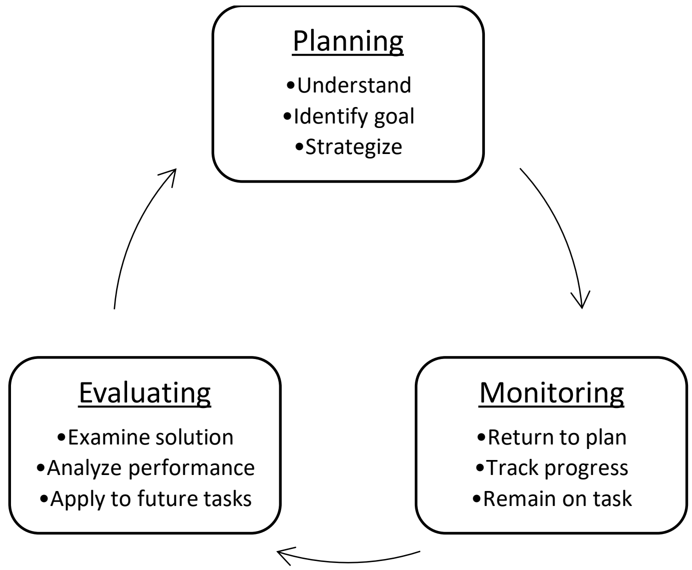

Figure 1: Stages and key features of each stage of metacognition. Adapted from Zepeda et al. 2015.

Utilizing the stages of metacognition has been linked to improved thinking skills and higher levels of academic success (Tanner 2012). It has also been shown to make students more independent learners and allow them to better adapt to changing demands, successes, and failures (Jacobs and Paris 1987). Medical educators have also found that individuals who exhibit higher levels of metacognitive skill are better equipped to make the types of judgements and to exhibit the cognitive control needed to be a successful physician and clinician, yet they have found that these skills are rarely being taught in medical education (Colbert et al. 2015). Of course, the benefits of metacognitive awareness are not reserved only for the medical field, as the stages may be applied in any career as expert problem solving ability and critical thinking are becoming increasingly more important (Schraw et al. 2006). Thus, just from these few examples of potential benefits of metacognition, one can see how, if successful, a program to improve student metacognition would be highly warranted and advantageous.

The established and most commonly used measure of metacognition level is the Metacognitive Awareness Inventory (MAI). The original MAI is a 52 item-long, self-report survey that scores individuals based on their responses to learning-strategy related statements. Different versions of the survey, using True or False statements or Likert Scale scoring, are available. However, a recent study found that the entire 52-item instrument may not be the best fit for measuring metacognitive awareness. However, 19 of the original 52-items were found to be adequate for measurement purposes (Harrison and Vallin 2018). The shortened 19-item survey employed in this study can be found in the Appendix. The shortened MAI provides a more efficient and less time-consuming survey for participates without sacrificing on the accuracy of the measurement. In addition, metacognitive awareness correlates with broad measures of academic performance, including overall course grades in college-level courses and GPA (Young and Fry 2008). This study supports the use of broad measures of academic performance in evaluating metacognitive awareness. Based on these two studies, MAI scores and academic statistics such as GPA and course grades will be used to measure metacognitive awareness.

There are few studies that have tested whether a metacognition training program can be used to improve student metacognition and academic performance. Even fewer studies, still, focus on college students as the target of the training. These two voids in our understanding highlight the importance of and unique opportunity for studies to begin to fill this gap. A few of the existing, pertinent studies on metacognition are summarized in the next paragraph.

Stanton et al. (2015) sought to determine if instructing students on metacognition can be effective for all students, each of whom brings a unique learning background to the table. The researchers monitored students' responses to multiple guided metacognition worksheets given throughout the semester and monitored their implementation of metacognitive strategies. Their results found that while metacognition can be improved in some students simply by prompting, other students may require more detailed, guided instruction on how to be more metacognitive (Stanton et al. 2015). Additionally, this study shows that, while each student brings unique experiences with learning and metacognition to the table, they can all benefit from direct instruction on the topic. Zepeda et al. (2015) conducted a study on a population of eighth-grade students, using self-guided packets containing explanations of metacognitive and its stages—planning, monitoring, and evaluating—and problem-solving activities that allowed students to practice the topic that was introduced in the packet. While this study found no significant improvement in scores on the MAI or increase in student usage of metacognitive strategies, the students' declarative knowledge on the topic of metacognition and its stages did improve. (Zepeda et al. 2015). These studies demonstrate both the applicability and the necessity of a study like this one to see if a different approach to metacognition training might be more effective in improving student metacognition.

The purpose of this project is to explore the impacts of metacognition training on student performance and learning outcomes. To do this, I plan to create a series of training videos that introduce and discuss the topic of metacognition, as well as each of the stages, planning, monitoring, and evaluating. My hypothesis is that students who complete the training program will see improvements in academic performance compared to their peers who did not participate in the study and that they will show an increase in metacognitive awareness as well. If the data support this hypothesis, the training modules can continue to be utilized in this course and can be expanded to other courses in the future.

CHAPTER TWO

Material and Methods

Course Description

A newly created lecture/lab course (BIO 1405) in the department of Biology at Baylor University provided an ideal opportunity to in which to conduct this study. This course includes a three-credit-hour lecture component in addition to a one-credit-hour laboratory component. The lecture course follows the traditional aim of investigating introductory biological concepts, with an emphasis on cell biology, metabolism, and genetics. The laboratory portion of the course, the students work in small groups on inquiry-based projects of their own design covering the same biological topics. Students attended the same lecture class but were divided between four laboratory sections, which took place at different times on the same day of the week. A schedule of laboratories plus the number of students in each section are outlined in Table 1.

Table 1: The breakdown of laboratory sections for this course according to the section letter, time of day the section meets, and number of students in the section.

Course Section:	Time:	Number of Students:
A	8:00am-9:55am	13
B	10:10am-12:05pm	20
C	12:30pm-2:25pm	9
D	2:40pm-4:35pm	15

Study Activities

The control and experimental groups for this project were chosen so as to create groups that were approximately the same size. Sections B and C (n = 29) were selected as the experimental groups and participated in the metacognition training modules and quizzes. The metacognitive training video modules and quizzes replaced a previously established portion of the course, Learning Theory. Sections A and D (n = 28) were selected as the control groups and received no metacognition training. Instead, they would continue to do existing assignments the professor had used in previous years, all of which fell under the broad category of Learning Theory. This includes assignments such as reading short articles discussing creativity in science or looking at a PowerPoint presentation over mind set and taking an online quiz. This ensured that the workload was fair and approximately equal for both groups. Participation in the experiment was required as part of their coursework and grades were assigned based on their completion of the activities to ensure their best efforts on all activities. These module quiz grades, in addition to the other pre-lab quizzes and assignments required by the professor, would factor into the "Pre-Lab" category of their course, which counts as 20% of their grade in the laboratory.

The experimental group was assigned a short tutorial video about 5 minutes in length to watch on designated weeks throughout the semester (see Table 2), followed by a short quiz. These videos focused on a certain stage of the metacognitive process and then applied the metacognitive strategies discussed to a scientific topic that is relevant to their course. The assignments completed outside of class and lab time were due at the beginning of the students' lab period on the indicated weeks. Each assignment was approximately ten minutes in length. The breakdown of topics, the timeline for completion of the assignments, and the activities for each week can be found in Table 2.

Table 2: The breakdown of the schedule of assignments for the control group. The table shows due dates, topics, and activities.

Week of the Semester:	Stage of Metacognition Discussed:	Topic Applied to:	Assignment:
3	Introduction to Metacognition	None	Video, Quiz, MAI Survey
4	Planning	Scientific Writing	Video + Quiz
5	Monitoring	Scientific Writing	Video + Quiz
6	Evaluating	Scientific Writing	Video + Quiz
7	Integrating	Statistical Tests	Video + Quiz
8	Planning	Ciliate Classification	Video + Quiz
9	Monitoring	Ciliate Classification	Video + Quiz
11	Evaluating	Ciliate Classification	Video + Quiz
12	Integrating	Scientific Reading	Video, Quiz, MAI Survey

Data Collection

A Metacognitive Awareness Inventory (MAI) survey was sent to both the experimental and control groups at the beginning of the semester. The same survey was completed by both groups towards the end of the semester. The change in score from pre to post assessed individual metacognitive levels and tracked development across the semester, with a higher score on the MAI indicating a higher level of metacognitive skill. Standard descriptive data were also collected on the participants. Student exam grades and overall course grades were also collected for analysis. Data was also gathered from the online module quizzes taken by the experiment group. Survey questions and an example of the quizzes can be found in the Appendix. A variety of statistical tests appropriate for this data were performed to compare the control and experimental groups and to identify if significant improvements in academic performance and/or metacognitive awareness occurred by participating students.

IRB Approval

An IRB Exemption Application and the appropriate documents were completed and approved for this project. Consent was not required for the students to participate in the study activities, as they were part of an established course. Consent was required to access the students' grades. This was collected in survey format at the conclusion of the semester.

CHAPTER THREE

Results

Descriptive Data

Following the exclusion of non-consenting participants, 26 students remained in the control group and 27 students remained in the experimental group. Descriptive data, including gender identity, age, school year classification, and ethnicity were collected from the self-report survey given to all students at the beginning of the semester. The data included if they were first generation college students, if this was their first science class at the university level, and if they planned on attending graduate school of any kind following graduation. This data, separated into control and experimental groups, can be found in Tables 3 and 4 respectively.

Table 3: Descriptive, biographical data collected from a self-report survey given to both the control and experimental sections at the beginning of the semester.

	Male (%)	Female (%)	First College Science Course Taken (%)	Freshman (%)	First Generation College Student (%)	Planning on Attending Graduate School (%)	Average Age (Years)
Control	44.4%	55.6%	92.6%	100%	14.8%	85.2%	17.96
Experimental	37.9%	62.1%	79.3%	100%	13.8%	72.4%	18.03

Table 4: Self-reported ethnic identities from a survey given to both the control and experimental sections at the beginning of the semester.

	White/Caucasian (%)	Asian (%)	Hispanic (%)	African American (%)	Multiple/Other (%)
Control	25.9%	48.1%	22.2%	0.0%	3.7%
Experimental	51.7%	10.3%	20.7%	10.3%	6.9%

Quantitative Data

Each week, students in the experimental group watched videos and completed quizzes based on the content of the video. The experimental group's video covered topics related to metacognition as it related to their activity in the laboratory. An example quiz can be found in the Appendix. Table 5 shows the order of topics, the length of each video, and the average amount of time students watched the video and completed the quiz.

Table 5: Order of topics, length of each training video (in seconds) and the average time (in seconds) spent by the students in the experimental group on each of the Canvas Quizzes associated with the training module videos.

Name of Video	Length of Video in Seconds	Average Time Spent on Video and Quiz in Seconds
Intro to Metacognition	202	998
Planning 1	215	551
Monitoring 1	196	452
Evaluating 1	297	545
Integrating 1	335	746
Planning 2	199	2260
Monitoring 2	233	510
Evaluating 2	228	2145
Integrating 2	317	5715

Comparisons between the two student populations including final grades in the laboratory, lecture, and overall score, plus changes in scores on the MAI before and after exposure to the metacognitive training were made using two-sample T-tests assuming unequal variances with a significance of 0.05.

An initial T-test was performed with the MAI outcomes prior to beginning the experiment to ensure that students in both groups had an equal initial understanding of metacognitive principles. The T-test showed no significant difference between the groups total score on the MAI ($p=0.154$). Additional T-tests were performed comparing the total metacognitive awareness scores for the individual stages of planning, monitoring, and evaluating, as these were the aspects of metacognition specifically addressed in the training modules and videos. The differences between the groups in each category are displayed in Figure 2. The results from the t-test can be found in Table 6. The p-values for the T-tests comparing planning score, monitoring score, and evaluating score were 0.231, 0.238, and 0.0232, respectively. While there was no significant difference reported between the control and experimental groups with regards to the planning and monitoring stages of metacognition ($p\text{-value}>0.05$), the experimental group had a significantly lower score ($p\text{-value}<0.05$) in regard to the evaluating stage of metacognition prior to receiving the training.

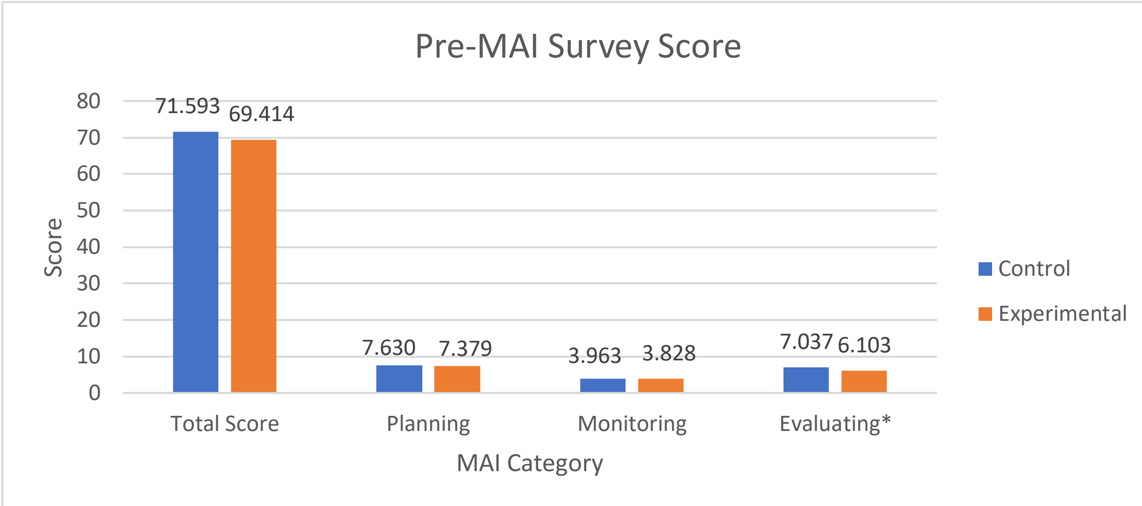

Figure 2: Differences in total MAI, planning, monitoring, and evaluating scores between the control and experimental groups prior to experimentation. *Denotes a significance difference ($p<0.05$).

Table 6: Results of a series of T-tests performed to evaluate the differences in scores between the control group and experimental groups prior to any experimentation.

		Control	Experimental
	Mean	71.5925926	69.4137931
	Variance	46.7122507	79.75123153
Total MAI Score	t Stat	1.02937155	
	P(T<=t) one-tail	0.15403474	
	t Critical one-tail	1.67468915	
	P(T<=t) two-tail	0.30806947	
	t Critical two-tail	2.00664681	
	Mean	7.62962963	7.379310345
	Variance	1.3960114	1.815270936
Planning Score	t Stat	0.74040921	
	P(T<=t) one-tail	0.23112951	
	t Critical one-tail	1.67356491	
	P(T<=t) two-tail	0.46225902	
	t Critical two-tail	2.00487929	
	Mean	3.96296296	3.827586207
	Variance	0.42165242	0.57635468
Monitoring Score	t Stat	0.71859575	
	P(T<=t) one-tail	0.237744	
	t Critical one-tail	1.67356491	
	P(T<=t) two-tail	0.475488	
	t Critical two-tail	2.00487929	
	Mean	7.03703704	6.103448276
	Variance	1.96011396	3.95320197
Evaluating Score	t Stat	2.04254538	
	P(T<=t) one-tail	0.02319399	
	t Critical one-tail	1.67590503	
	P(T<=t) two-tail	0.04638797	
	t Critical two-tail	2.00855911	

After establishing that the experimental group was not initially starting with higher metacognitive awareness scores, t-tests were performed comparing the total MAI, planning, monitoring, and evaluating scores at the beginning and end of the semester for both the control and experimental sections, thus determining changes throughout the semester. Figures 3a and 3b show the difference between the groups. These tests would show if there was any significant change in metacognitive awareness in either group throughout the semester. The results of the T-tests that were performed are summarized in Table 7a and 7b, below. The results of the T-tests for the control group yielded p-values of 0.216, 0.216, 0.286, and 0.291 for the total MAI, planning, monitoring, and evaluating scores, respectively. These p-values indicate that there was no significant change ($p<0.05$) in any of these categories for the control group across the semester, as all of the p-values are greater than 0.05. The same series of T-tests were performed for the experimental group and yielded p-values of 0.411, 0.338, 0.0423, and 0.0709 for the total MAI, planning, monitoring, and evaluating scores, respectively. The p-values for the total MAI score and the planning score were greater than 0.05, indicating no significant improvements in these categories before and after completing the training modules. The difference between the scores in the evaluating category were also non-significant ($p>0.05$), but as the p-value was low, the data was approaching significance. Lastly, the p-value from the T-test comparing the difference in monitoring score before and after metacognition training was 0.0423, indicating a significant difference in monitoring score before and after the experimental group completed the training modules.

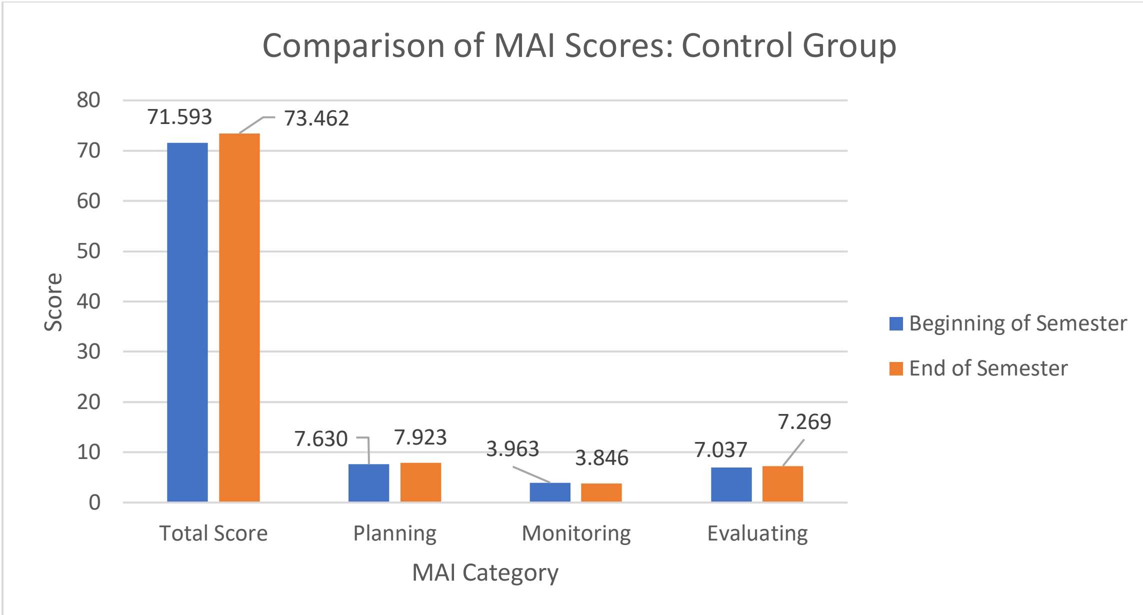

Figure 3a: MAI Score by category for the control group at the beginning of the semester compared to the end of the semester.

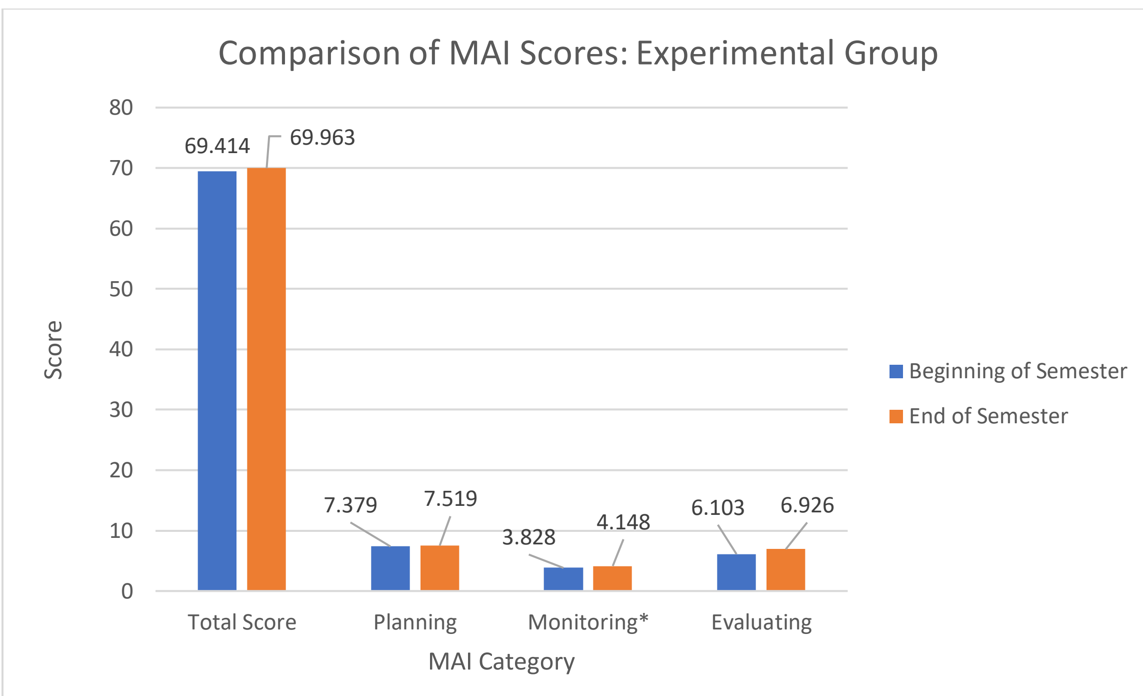

Figure 3b: MAI Score by category for the experimental group at the beginning of the semester (prior to training) compared to the end of the semester (after training). *Denotes a significant difference ($p<0.05$).

Table 7a: The results of a series of T-tests performed to evaluate the differences between the total MAI, planning, monitoring, and evaluating scores of the control group at the beginning and end of the semester.

		Pre	Post
Total MAI Score	Mean	71.5925926	73.4615385
	Variance	46.7122507	99.7784615
	t Stat	-0.7920602	
	P(T<=t) one-tail	0.21628764	
	t Critical one-tail	1.68022998	
	P(T<=t) two-tail	0.43257529	
	t Critical two-tail	2.01536757	
Planning Score	Mean	7.62962963	7.92307692
	Variance	1.3960114	2.23384615
	t Stat	-0.7910197	
	P(T<=t) one-tail	0.21641189	
	t Critical one-tail	1.6772242	
	P(T<=t) two-tail	0.43282377	
	t Critical two-tail	2.01063476	
Monitoring Score	Mean	3.96296296	3.84615385
	Variance	0.42165242	0.69538462
	t Stat	0.56752746	
	P(T<=t) one-tail	0.28652848	
	t Critical one-tail	1.67792672	
	P(T<=t) two-tail	0.57305696	
	t Critical two-tail	2.01174051	
Evaluating Score	Mean	7.03703704	7.26923077
	Variance	1.96011396	2.68461538
	t Stat	-0.5537041	
	P(T<=t) one-tail	0.29114968	
	t Critical one-tail	1.67655089	
	P(T<=t) two-tail	0.58229937	
	t Critical two-tail	2.00957524	

Table 7b: Results of a series of T-tests performed to evaluate the differences between the total MAI, planning, monitoring, and evaluating scores of the experimental group at the beginning and end of the semester.

		Pre	**Post**
	Mean	69.4137931	69.962963
	Variance	79.7512315	84.1908832
Total MAI Score	t Stat	-0.226701	
	P(T<=t) one-tail	0.4107642	
	t Critical one-tail	1.67411624	
	P(T<=t) two-tail	0.82152839	
	t Critical two-tail	2.005746	
	Mean	7.37931034	7.51851852
	Variance	1.81527094	1.25925926
Planning Score	t Stat	-0.421196	
	P(T<=t) one-tail	0.33765761	
	t Critical one-tail	1.67411624	
	P(T<=t) two-tail	0.67531521	
	t Critical two-tail	2.005746	
	Mean	3.82758621	4.14814815
	Variance	0.57635468	0.36182336
Monitoring Score	t Stat	-1.7573241	
	P(T<=t) one-tail	0.04231881	
	t Critical one-tail	1.67411624	
	P(T<=t) two-tail	0.08463762	
	t Critical two-tail	2.005746	
	Mean	6.10344828	6.92592593
	Variance	3.95320197	4.53276353
Evaluating Score	t Stat	-1.4912358	
	P(T<=t) one-tail	0.07091396	
	t Critical one-tail	1.67411624	
	P(T<=t) two-tail	0.14182791	
	t Critical two-tail	2.005746	

Lastly, T-tests were performed to determine if differences exist between the course grades of the two groups. The BIO 1405 course consists of a one-credit-hour lab portion, which accounts for 25% of the overall average, and a three-credit-hour lecture portion, which accounts for 75% of the overall average. T-tests were performed using grades from the lab portion and lecture portion separately, as well as the overall course grades. The comparisons between the two groups are shown in Figure 4. The results of these T-tests are summarized in Table 8. The T-tests that compared the lecture grades and the overall grades of the control and experimental groups yielded p-values of 0.460 and 0.446, respectively. P-values greater than 0.05 indicate no significant difference between the lecture grades or overall grades of the control and experimental sections. However, the T-test comparing the average lab grades between the control and experimental groups generated a p-value of 0.0623. While this value is still insignificant (p-value>0.05), it is approaching significance (p-value<0.05).

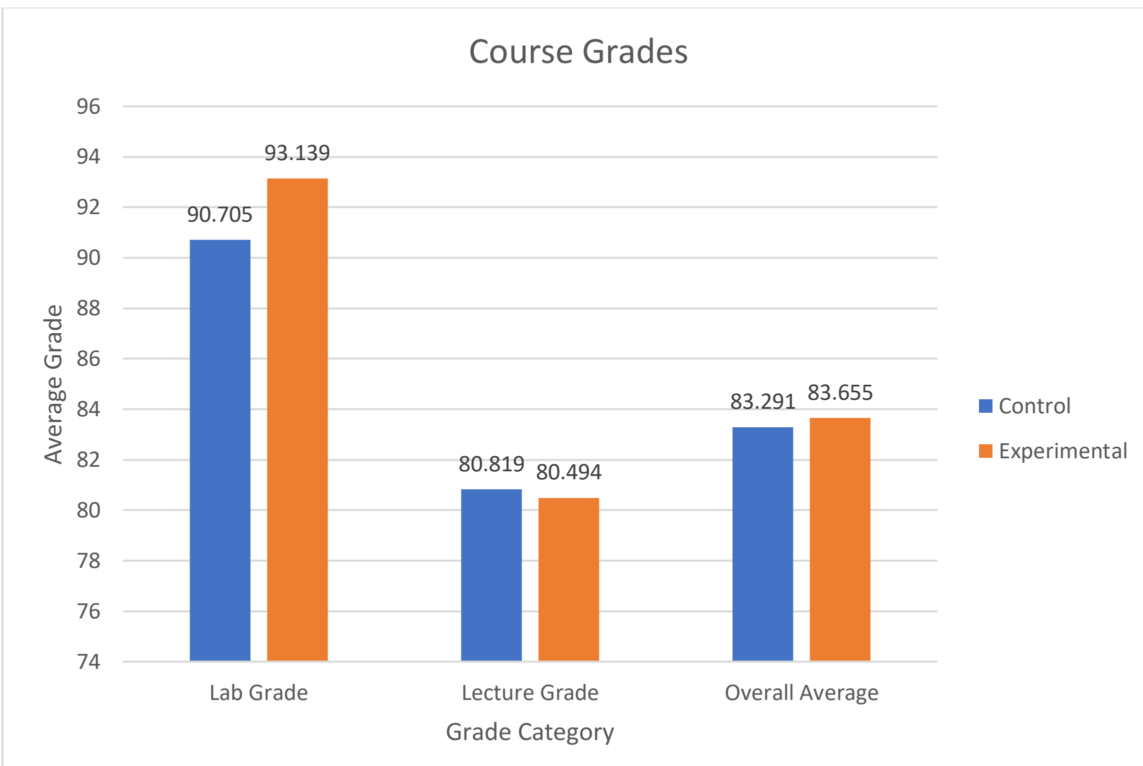

Figure 4: A comparison of lab grades, lecture grades, and overall averages between the control and experimental groups.

Table 8: Results of a series of T-tests performed to evaluate the differences in academic performance between the control and experimental groups.

		Control	Experimental
	Mean	90.7053846	93.13888889
	Variance	22.1130978	42.47371795
Lab Grade	t Stat	-1.5631521	
	P(T<=t) one-tail	0.06236289	
	t Critical one-tail	1.67792672	
	P(T<=t) two-tail	0.12472578	
	t Critical two-tail	2.01174051	
	Mean	80.8191068	80.49389258
	Variance	101.351969	173.8835711
Lecture Grade	t Stat	0.1011452	
	P(T<=t) one-tail	0.45992397	
	t Critical one-tail	1.67655089	
	P(T<=t) two-tail	0.91984795	
	t Critical two-tail	2.00957524	
	Mean	83.2906762	83.65514165
	Variance	69.799725	121.4379867
Overall Grade	t Stat	-0.1359954	
	P(T<=t) one-tail	0.44619683	
	t Critical one-tail	1.6772242	
	P(T<=t) two-tail	0.89239366	
	t Critical two-tail	2.01063476	

CHAPTER FOUR

Discussion

The goal of this study was to determine if, through a series of videos and quizzes focused on the three aspects of metacognition (planning, monitoring, and evaluating), students could be trained in metacognition. It was hypothesized that those students who received this training would show improvements in metacognitive awareness (measured using the Metacognitive Awareness Inventory) and improved academic performance in their introductory biology course. Overall, the data supports parts, but not all, of the hypothesis.

With regard to metacognitive awareness, the data showed a significant increase in monitoring skill in our experimental group ($p=0.0423$) and an increase in evaluating skill in our experimental group that was approaching significance ($p=0.0709$). These p-values suggest that the training modules were effective in improving students' awareness and utilization of monitoring skills, such as periodically reviewing to help oneself understand important relationships. The fact that the p-value for the evaluation aspect of metacognition was approaching significance indicates that further testing is warranted. Given a larger sample size, we may see a significant improvement in students' awareness and utilization of evaluation skills, which including things such as summarizing what one has learned after finishing and asking oneself if you have learned as much as you could have after finishing a task.

In regard to academic performance, students' overall course grades, as well as grades in the lab and lecture components of the course were evaluated. While it was hypothesized that overall grade, lab grade, and lecture grade would all be significantly higher in the experimental group than in the control group, the data showed that this was not the case. The experimental group did not perform significantly better than the control group in any of these categories. However, the p-value for the lab portion of the course was 0.0623. While still insignificant, this number is approaching significance. Given further testing and a larger sample size, it is my opinion that the data could reach significance. One possible explanation is that the training modules were completed as a requirement of the lab portion of the course and although some of the topics discussed in the videos applied to lecture material as well, students may have had a difficult time transferring the information and metacognitive skills. This implies that a possible next step for this project would be to utilize the training modules in both lecture and lab portions of the course. This may increase students' ability to see the material as relevant to all aspects of their studies as they apply these skills.

Although every attempt was made to control for variables that may have impacted our data and results in some way, there are some potential confounding variables that still may have altered our results. As is the case with any self-report survey, the Metacognitive Awareness Inventory scores may have been impacted by students responding in a biased or inaccurate way. In an attempt to ensure that the grades of participants would not suffer due to their participation, the quizzes associated with the training modules were made to be completion grades. However, without the motivation of receiving a real grade, students may have paid less attention to the training modules or taken them less seriously. Lastly, the lab sections were assigned randomly so as to have approximately an equal number of students in each group. However, we could not assign students to their lab sections. Assigning whole lab sections versus individual students may have altered the data in an unknown way.

The results of this study, while they do not entirely support the hypotheses, are promising. They showed that it is possible to impact the academic performance and metacognitive awareness through online training videos. Because of the findings, it is worth repeating and potentially redesigning parts of the project so that we may elucidate benefits and individual improvements for all participants.

The results have also revealed a number of ways that this study and the training modules could be improved upon in the future. Randomly selecting students for the control and experimental groups would help to eliminate possible confounding variables. Additional testing and a larger sample size would allow for a more robust analysis of data and confirm the trends that were found in this study. Based on the results, we recommend utilization of the training modules in lecture courses as well, hopefully increasing transfer and application of new metacognitive skills. It also may be beneficial to incorporate the modules in such a way that they more directly impact the grades of the students. This may cause the students to take the modules more seriously and pay more attention to the content being presented. Lastly, it is recommended that this study become a longitudinal study. By following the participating students across their undergraduate career, we could collect further information on the impact of training on academic performance, such as overall and science GPA, post-graduation plans, and their continues use or disuse of metacognition.

There were also many other interesting variables that we collected during this study but, due to the scope of this project and associated time limitations, were unable to fully flush out. The demographic information that we collected, such as age, race, generation, and status as a first-generation college student, could all be analyzed for potentially interesting connections to metacognitive awareness and the impact of the training modules. Analyzing for relationships between these variables would also be a potential next step for this project.

This preliminary study gave us insights into the way to students can be taught to apply metacognitive skills in their everyday studies and the impact that this can have on their academic performance. Given further research and improvements to the training modules and the study as a whole, we may see even more benefits for students in regard to complex thinking skills and academic performance. Because of the importance of these two things to both success as a student and as a future member of the workforce, further studying of this subject would be greatly advantageous.

APPENDICES

APPENDIX A

Metacognition Awareness Inventory (MAI) Survey Questions

	Never	Rarely	Sometimes	Often	Always
I think about what I really need to learn before I begin a task.					
I set specific goals before I begin a task.					
I know what kind of information is most important to learn.					
I know what the teacher expects me to learn.					
I periodically review to help me understand important relationships.					
I summarize what I learn after I finish.					
I can motivate myself to learn when I need to.					
I am aware of what strategies I use when I study.					
I am a good judge of how well I understand something.					
I find myself using helpful learning strategies automatically.					
I know when each strategy I use will be most effective.					
I try to translate new information into my own words.					
I change strategies when I fail to understand.					
I use the organizational structure of the text to help me learn.					
I ask myself if what I'm reading is related to what I already know.					
I re-evaluate my assumptions when I get confused.					
I ask myself if I have learned as much as I could have once I finish a task.					
I stop and go back over new information that is not clear.					

APPENDIX B

Sample Module Quiz Questions

Planning Quiz 1

1. Metacognition is a very active process.

   a. True

   b. False

2. Which of the following is done during the planning stage of metacognition?

   a. Organizing the given information

   b. Understanding the problem

   c. Identifying the goal

   d. Creating a plan

   e. All of these are done during the planning stage

3. What scientific topic was discussed in the week's video?

   a. Statistical tests

   b. Scientific writing

   c. Ciliate classification

   d. Scientific reading

4. It is important to write down your plan to increase your own accountability and so that you can return to it during future stages of metacognition.

   a. True

   b. False

5. Which of the following was not done in this video to demonstrate the planning stage of metacognition?

a. Reading and reviewing similar reports and articles

b. Assessing your progress through the plan

c. Writing out the goal

d. Creating a timetable/schedule

e. Listing out the requirements of the project

f. Breaking the large plan into smaller plan

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