Metacognitive Regulation Intervention(s) in Undergraduate Science Instruction

Education Seminar Research Thesis

Rachel Hanebutt

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Abstract

Of increasing importance to DePauw University, its science faculty, current and potential students, metacognitive regulation, by definition, refers to adjustments individuals make in their processes to control their own learning. The ability to make such adjustments, realize the utility of metacognitive strategies, and ultimately apply knowledge of metacognition to their academic lives, is often trivialized and neglected by both faculty and students. This is especially common for undergraduates in the sciences, complicating requirements (i.e. SM credit), which mandate course exposure to science thinking, comprehension, and application. This project seeks to analyze DePauw students' current understanding and usage of metacognition and includes three different metacognitive regulation interventions to assess strategies of instruction for the general science course currently being constructed. Increased knowledge and awareness of metacognitive strategies in course instruction will ultimately enhance and improve future DePauw science course effectiveness, accessibility and retention.

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1. INTRODUCTION/PROJECT BACKGROUND

Introduction

Originating in developmental psychology with the work of John Flavell (1979), metacognition has become the basis for many instructional discussions in education. Metacognition, the process of being self-aware of one's own thinking/knowledge, is important in science because it dispels insecurities of misunderstanding, which can become a barrier to learning new concepts. Integrating metacognition into science curriculum not only allows students to be aware of what they know, but also allows them to become confident in what they know, thus, increasing the likelihood of student success in the sciences. Student confidence can lead not only to success, but also to a greater enjoyment and understanding of what is studied. Especially present during developmental phases that occur in years as an undergraduate, it is very important that students learn how to think about their own thinking as well as to learn how to think in a scientific way. Failure to effectively instill this way of thinking will affect a student's future in more ways than one.

Project Background

Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn; or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other

courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."

Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I also started taking education courses because I had always been interested in the history of education and how it has changed. Learning about various education processes in EDU 170: Foundations of Education, and continuing to learn about specific developmental theories in EDUC 222, I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

My passion for this research topic stems from this frustration. It also stems from the revelations I experienced after taking education courses and truly able to understand why my mind seemed to be shutting down when it came to science. Embracing Liberal Arts and its advantages, this project is truly the culmination of my own intellectual and academic experience at DePauw.

Purpose

An amalgamation of DePauw University science faculty/departments is currently exploring the possibility of creating a general science education course for non-science majors. Research of this topic, as well as noting the pertinence of developmental theories in constructing course curriculum, is important for course development. More specifically, the addition of a

science course that utilized metacognitive approaches of instruction in the undergraduate context is vital for engaging more students in much needed science, technology, engineering, and mathematics (STEM) fields. Further research of metacognitive regulation in undergraduate science course instruction could have real implications for current and future DePauw students.

Another purpose of this research is to explore the impacts that metacognition has in the science-learning context. Metacognition, in its simplest definition, is awareness of and understanding of one's own thought processes. Science instruction that is cognizant of metacognitive strategies might enhance student understanding. Enhanced understanding would inevitably increase the likelihood that students would enjoy and continue work in the sciences. Student retention in the hard sciences is incredibly important, not just because of the increasing amount of science careers, but also from the university admissions standpoint. Undergraduate institutions, in particular, must have an investment in providing students with effective ways to learn and think scientifically. The incorporation of metacognitive strategies in instruction might be one way to accomplish this. Thus, study of metacognitive approaches in science course instruction will be the focus of my research.

Goals of the Project

Focusing on undergraduate metacognition awareness and regulation, this project undertakes the question of whether metacognition plays a role math and science undergraduate courses and endeavors to survey the ways in which metacognitive skills and awareness can be regulated in the classroom. Ultimately, the goal of this project is to evaluate three metacognitive regulation interventions so to better inform future DePauw math and science course instruction methods. Additionally, this project will assess student metacognition in terms of study habits and effectiveness of various learning strategies.

2. RESEARCH RATIONALE AND GUIDING QUESTION(S) AND SUB-QUESTION(S)

Question Overview:

- Is "metacognitive regulation intervention(s)"[1] an effective implementation for undergraduate science course instruction?
    - Is metacognitive regulation intervention(s) in undergraduate science course instruction effective?
    - What types of metacognitive regulation intervention(s) can/should be used in undergraduate science course instruction?

Question Framework:

The framework of this research's central question is built around ideas in the growing field of cognitive science in education. Use of metacognitive strategies in the classroom can ultimately alter the ways in which student learn, think about their learning, and strategically learn from their own learning. Studying the importance and types of metacognitive regulation that could be the most useful for undergraduate students is the first step in incorporating effective metacognitive regulation intervention into a curriculum for general science instruction and course instruction as a whole.

Central Question: *Is metacognitive regulation an effective implementation for undergraduate science course instruction?*

Origin/Relevance: This question originates with the very idea of incorporating metacognitive regulation strategies in undergraduate science instruction, itself. One must know

[1] "Metacognitive regulation intervention" is a term created by the researcher for use in this study.

the ways in which a theory can be applied before he or she is able to evaluate its importance, or lack thereof.

Personal Interest/Effect: This question will allow me to "answer" my most pressing questions about metacognition in the undergraduate science context. My own experience and difficulties with undergraduate-level sciences was ultimately demystified once I learned about metacognition and metacognitive regulation strategies. This is not an excuse for my change in major, but rather a way to understand what I was going through. This study is a way to assess current student awareness of their thinking processes, as well as to enlighten others about their own mental/cognitive processes and the strategies, which could be employed to improve them.

Development: This question develops from my initial questions about whether metacognitive regulation intervention(s) should hold a place in undergraduate science instruction. It develops from the assumption that metacognition can be incorporated or taught: a theory, which my research will hopefully support. It also develops from a long history of students dropping from undergraduate science programs because of their feelings of hopelessness and lack of knowledge in regards to their own learning. This type of instruction could potentially guide them to understand their own thinking, and to develop a new outlook on science thinking.

Expected Learning Outcome: I expect to learn how metacognitive regulation intervention fits into the puzzle, which is undergraduate science instruction. While the cognitive sciences has not always played a major role in instruction curriculum, I expect to uncover a plethora of reasons as to how metacognitive regulation interventions, when implemented effectively, are able to complement and supplement current practices and innovations in science instruction.

<u>Sub-Question #1:</u> *Is metacognitive regulation intervention(s) in undergraduate science course instruction important?*

Explanation: This question seeks to uncover whether the ability of metacognition is even important in undergraduate science course instruction. It comes from a rather obvious notion that an instruction method not worth doing/ineffective is not needed in the classroom. While my research could potentially support that metacognitive regulation interventions can be employed in undergraduate science instruction, it is also important to know whether or not this intervention is necessary.

Expected Learning Outcome: I expect to find out whether metacognition is viewed as an important approach in undergraduate science instruction. Hopefully, my research will make the case for metacognition in science courses.

<u>Sub-Question #2:</u> *What types of metacognitive regulation intervention(s) can/should be used in undergraduate science course instruction?*

Explanation: This question seeks to answer the practical piece of my research. If I am able to prove both the ability and need of metacognitive regulation in science instruction, it will be additionally important to explore effective theories or strategies of this practice of intervention.

Expected Learning Outcome: I expect to find out what types of metacognitive regulation interventions should be utilized in the context of an undergraduate science course. I expect to find tested examples, and for my research to support these examples, at least theoretically.

Result of Central Question and Sub-Questions:

Research and discussion of these questions will formulate an analysis of metacognitive regulation in undergraduate science course instruction. Further study of metacognition in

general will enable additional insight into effective teaching styles and learning strategies, as very few studies struggle to effectively quantify metacognition regulation and evaluation. This project could ultimately influence current university courses, which in turn, will alter the experience DePauw students have with science courses and science thinking. Additionally, this targeted research on math and science metacognition will contribute to pre-existing literature and research and might potentially influence future curriculum and course instruction methods.

3. LITERATURE REVIEW

Metacognitive Regulation in Science Instruction

"Learning how to learn cannot be left to students.

It must be taught (Gall *et al.*, 1990)."

Introduction

In order to fully understand, assess, and analyze student learning in any field, it is important to understand the cognitive processes and nature of thinking involved in these ways of learning. This study of metacognitive regulation will explore the definitions of metacognition; history of metacognitive regulation; relationship between metacognition and science learning; and viable instruction of metacognitive regulation in the classroom. Through evaluation of this literature, this review will help to gain a deeper insight into metacognition and its role in science thinking and instruction.

Definitions of Metacognition

The main challenge in metacognition research lies in the very definition of what metacognition *is*. Closely intertwined with self-regulation, a seeming synonym of intellectual reflection, and a component of introspection, metacognition is the very complex practice of cognition about cognition. Explanation of metacognition, metacognitive strategies, and

metacognitive regulation, however, becomes a paradox, as a personal understanding of metacognition is necessary for definition and comprehension of this aspect of thinking. The origin of the word "metacognition," however, finds its root from the Greek, *meta-*, meaning *beyond.* Various thinkers offer their individual definitions of the term metacognition. Yet, it is only through analysis and integration of these definitions that one can dive deeper into assessing metacognitive strategies and their effectiveness in the classroom.

The "Father of Metacognition," John H. Flavell is known for building upon research involving human memory, "transferring the interest in what humans know about their own memory to what they know about their own cognitive processes" (Rysz, 2004). Flavell's definitional example of metacognition provides: "I am engaging in metacognition if I notice that I am having more trouble learning A than B; if it strikes me that I should double check C before accepting it as fact" (Flavell, 1976). While this anecdote provides a tangible example of what constitutes metacognition, it might also be useful to acknowledge the definitional space foundational theorists have applied to the theory of metacognition.

Piaget defines metacognition as, "knowledge of one's own thoughts and thought processes, involve[ing] both conscious awareness and the capability of communicating one's rationale" (Fox and Riconscente, 2008). According to Piaget, metacognitive thought is conscious and intentional; it is directed by the thinker, involves reflection, can be communicated, and requires peer-to-peer interaction for maturation. But most importantly, this theory operates throughout four turning points, the last of which "occurs when the child moves into thinking characterized by formal operations or hypothetico-deductive reasoning. Now the child becomes capable of metacognition in the sense of awareness of and reflective knowledge regarding her own thoughts and thought processes" (Fox and Riconscente, 2008). But Piaget's definition,

however foundational it might be, is supplemented by William James' definition of metacognition or the "stream of consciousness."

Defining the subject matter of metacognitive knowledge as 'Me,' James makes a critical distinction between the knower ('I') and the self as it is known ('Me'). Placing operation of metacognition into the realm of the self, this practice takes the form of "thinking about thinking;" metacognition is now contingent upon the self and its awareness. In addition, James likens metacognition to the common definition of introspection: "the looking into our own minds and reporting what we there discover" (James, 1890/91), claiming that metacognition becomes a habitual part of our mental processes.

No definition of metacognition could be complete without input from Lev Vygotsky, who elaborates on James and Piaget's interpretations by explaining, "we use consciousness to denote awareness of the activity of the mind—the consciousness of being conscious" (Vygotsky, 1986). This sense of consciousness also extends to an awareness of the structure of one's own thought processes and how one can control his or her "mental powers." Vygotsky claims that "intellectualization of intelligence," or the ability to think about one's thinking, requires exposure to scientific concepts provided by school instruction. While Piaget necessitates interaction with peers, James names metacognition as a mental habit, and Vygotsky advocates for the role of formal schooling in promotion of metacognition, it remains unclear as to how this theory can be employed in the classroom, or made sense of in the context of instruction.

A shared understanding of metacognition in the field of educational psychology splits study of this practice into types of knowledge: declarative knowledge and procedural knowledge, with the contested addition of conditional knowledge. Analysis of these types of knowledge will provide a greater insight into the definition of metacognition as a whole.

Declarative Knowledge

As defined by the TEAL Center of the American Institutes for Research, declarative knowledge is "knowledge of oneself as a learner—the factors that influence performance." In regards to metacognition, declarative knowledge establishes the knower's awareness as a learner and realizes that he or she can think about his or her own knowledge. Additionally, declarative knowledge plays a key role in metacognitive regulation interventions in that it is the foundation of both discussing metacognition and assessing student metacognition and metacognitive regulation abilities.

Procedural Knowledge

Procedural knowledge is "knowledge about strategies and other procedures" and the awareness of these strategies and procedures in one's learning process (TEAL Center, 2012). In regards to metacognition, procedural knowledge establishes the knower's awareness of strategies of learning and his or her own cognitive processes. In regards to metacognitive regulation interventions, procedural knowledge provides the currency by which to evaluate the types of interventions that students are aware of and are not familiar with.

Conditional Knowledge

In addition to declarative and procedural knowledge, the contested area of conditional knowledge is defined as "knowledge of why and when to use a particular strategy" (TEAL Center, 2012). Dependent on procedural knowledge (and on declarative knowledge by default), conditional knowledge allows an individual to strategically employ the information and tactics they are aware of within their own cognitive processes. In regards to metacognition specifically, conditional knowledge establishes the knower's awareness that he or she can actively decide and control which cognitive strategies best suit a certain learning task. In other words, conditional

knowledge allows the knower jurisdiction over and awareness of his or her cognitive processes. This becomes even more important in metacognitive regulation intervention in that conditional knowledge is the final result or goal of instructional methods aiming to improve a student's regulation of his or her own metacognition.

Most theoretical definitions condense these types of knowledge to metacognitive knowledge and metacognitive regulation. "Knowledge about cognition," also known as metacognitive knowledge, and "regulation of cognition," also known as metacognitive regulation make up the process of metacognition (Arslan and Akin, 2014). Metacognitive knowledge is the awareness, knowledge and deep understanding of mental and cognitive processes drawing from learning, reflection and experiences. In terms of types of knowledge, declarative and procedural knowledge make up what is metacognitive knowledge. This knowledge ultimately controls the initial awareness that the knower can access his or her own cognitive processes and realize his or her own strategies for learning. According to Arslan and Akin's *Metacognition: As a Predictor of One's Academic Locus of Control*, metacognitive knowledge is "positively associated with the dimensions of an internal academic locus of control," or believing that people make choices which affect their life circumstances (Arslan and Akin, 2014). By contrast, people who believe their circumstances are controlled by external forces have a harder time realizing their own metacognition and metacognitive regulation. As a result, metacognitive regulation is most simply defined by the conditional knowledge or strategies that a thinker (who believes he or she makes internal choices that can have an effect on his or her life circumstances or learning) is able to employ to their own cognitive processes.

For the purpose of my study and the remainder of this literature review, I will employ the definition of metacognition as "the awareness of one's own knowledge and one's ability to

understand, control, and manipulate one's cognitive processes."[2] This encompasses aspects of many theorists' definitions of metacognition, as well as acknowledges the presence of declarative knowledge (metacognitive knowledge), and procedural and conditional knowledge (metacognitive regulation). Metacognitive regulation is important for a knower to truly become the master of his or her own learning; therefore, this study focuses on metacognitive regulation strategies. Knowledge of these strategies will be tested and manipulated through the process of conducting "metacognitive regulation intervention(s)," which, by the researcher's definition, is "an instructional tool for enhancing an individual's metacognitive regulation, or the ability of the knower to strategically control his or her own cognitive processes in specific learning environments."[3]

History of Metacognitive Regulation Research

While John H. Flavell was the first to coin the term, "metacognition," the importance of metacognition in the process of learning can "be traced from Socrates' questioning methods to Dewey's twentieth-century stance that we learn more from reflecting on our experiences than from the actual experiences themselves" (Tanner, 2012). Historically, the academic study and research of metacognition and metacognitive strategies focused on "metamemory," or "the study of what children and adults know about how to remember and about their own memory functions and how such knowledge relates to memory performance" (Kuhn, 2000). In the 21st century, however, study of metacognition has expanded, focusing not only on memory, but also on the metacognitive strategies for regulating knowledge acquisition and higher-level learning. According to the combined studies of Anderson, Nashon, and Thomas in *Evolution of Research*

[2] This particular definition of "metacognition" will be used in this study and has been created by the researcher.
[3] The term and definition of "metacognitive regulation intervention" will be used in this study and was created by the researcher.

Methods for Probing and Understanding Metacognition, there are two definitional spaces or paradigmatic schools of thought in conceptualizing metacognition in terms of understanding and researching it as a cognitive practice: Positive-Decontextualist and Relativist-Contextualist.

Positivist-Decontextualist

The positivist-decontextualist school of thought employs research that has been conducted by the way of "elaborate designs and complex statistical analyses" (Anderson *et al.*, 2009). Research in this line of thinking often sees his influence of intervention in the classroom as irrelevant to the overall outcome of the study. Positivist-decontextualist thinkers also design experiments, which seek to eliminate self-directed processes, often using one method of understanding metacognition. This ultimately gives a simple answer to the complexity of individual student learning.

Relativist-Contextualist

In contrast, the relativist-contextualist school of thought operates under the assumption that factors such as intervention in the classroom, as well as individual learning styles are influential in the development of metacognition. Research in this mindset focuses on a qualitative and interpretive understanding of students' metacognition; "in the context of natural, purposeful activity so that ecologically valid solutions can be found to the real-life, educational problems of teachers and students" (Anderson *et al.*, 2009). More specifically, the relativist-contextualist approach is appealing to researchers of metacognition because it allows a strictly empirical and statistically driven analysis of this topic to be continually scrutinized. Acknowledging the uniqueness of every individuals' metacognition, relativist-contextualists fulfill the objective of understanding metacognition, its effect on student learning, and its development on a deeper level (Anderson *et al.*, 2009).

While this study will find basis in empirical data collected in the form of surveys, it will blend these two schools of thought in such a way that will allow a space both for quantitative and qualitative methodology, data collection, and data analysis. This mixed method approach will allow the study to assess current levels of metacognitive ability in a systematic way, but will also take into account the various factors at play in each students' metacognitive process. While no survey has the capacity to capture the perfect picture of an individual's internally realized metacognitive processes, it is important to use every means possible to assess metacognitive ability, in order to establish a baseline of student perception and to evaluate potentially effective intervention strategies.

Metacognition and Science Learning

According to Entwistle and McCune the, "lack of confidence in problem-solving can be addressed when teachers use metacognition teaching strategies as a means to promote students' academic success and encourage the idea of disposition to understand oneself." This realization stresses the importance of confidence in metacognition, or "understanding oneself," and the way one thinks. Metacognition, "is a significant predictor in science achievement and overall achievement" (Sperling et al., 2012), and therefore is important for science education and learning. However, confidence also plays a major part in both a student's understanding of the material and his or her ability to apply the material in the proper contexts. Some students, however, have grown to believe learning is equated with memorization, therefore in application-heavy subjects, such as math and science, pure memory-based approaches to learning fall short of what a student needs to learn and understand. Additionally, students might not even realize that they are not processing information in the best way, or that they are able to access their own

cognitive processes in the way metacognitive regulation suggests. This is where metacognitive knowledge and metacognitive regulation become important.

Expanding on this point, White and Frederikson explain, "Metacognitive skills enable the learner to understand science concepts removing misconception and strategies that are barriers to acquiring new concepts." It is when these barriers and misconceptions are enabled their position and encouraged that students experience a disconnection between the information they are learning and their own cognitive processes and understanding. Because problem-solving and applied understanding of knowledge is important for knowledge acquisition in math and science, it is important to realize the component of student confidence in this equation. Self-efficacy, or the "people's beliefs about their capabilities in accomplishing a desired type of performance" (Bandura, 1993, 1994), influences an individual's feelings, thinking, motivations, and behaviors; actions inherently important for any learning environment. A discussion of metacognition and self-efficacy relating to science learning in particular is warranted by this realization.

Metacognition and Self-Efficacy in Science

According to Yerdelen-Damar and Pesman's *Relations of Gender and Socioeconomic Status to Physics through Metacognition and Self-Efficacy*, "researchers studying metacognitive instruction should not ignore the importance of self-efficacy because the success of metacognitive instruction is dependent on self-efficacy." Additionally, this study suggests that students with higher levels of self-efficacy use more cognitive and metacognitive skills. Tying these findings into science-specific learning, Yerdelen-Demar and Pesman revealed "the relation of metacognition to achievement is dependent on self-efficacy whereas the relation of self-efficacy to achievement is independent of metacognition" in their study of the relationship between physics achievement, socio-economic status, and gender. Self-efficacy becomes an

important aspect of the metacognition equation, promoting the idea that believing in one's capabilities is important for development and regulation of metacognition.

Metacognitive Regulation Interventions and Importance

Discussion of metacognition in the classroom is challenged by the assumption that the role of a professor is to teach and enlighten their students in terms of the particular subject matter they are assigned or responsible for. Some faculty members believe that it is not their role to teach study strategies, or to make sure that students are learning in the proper manner. This does not mean that professors do not care about their students or that they do not give them valuable advice for studying material. Metacognitive ability and regulation become even more important in higher education because of the increasingly independent nature of undergraduate learning. In a sense, educators should utilize metacognitive regulation strategies because, "to make an individual metacognitively-aware is to ensure that the individual has learned how to learn" (Garner, 1988). The sooner students master their own cognitive processes through metacognition; the sooner students can truly begin *learning*.

A focus since the 1970s, Flavell's metacognition divides metacognitive knowledge into three categories: person variables, task variables, and strategy variables. Similar to the aforementioned types of knowledge and paradigmatic categories, Flavell's variables explain an individual's role with each variable more specifically. Viewing the parts of metacognition as "variables" rather than simply types of knowledge, allows researchers to recognize the inherently individualistic characteristics of each step of this practice. Following this line of thinking, metacognitive regulation, or the adjustments an individual makes to their processes to help control their learning, takes the form of strategies the individual has learned to employ.

Metacognitive regulation interventions, the focus of this study, must then rely upon a vast scope of research and ideas, so to allow access to metacognition to a diverse population of individuals.

A term coined in Karlen, Merki and Ramseier's study, *The effect of individual differences in the development of metacognitive strategy knowledge*, metacognitive strategy knowledge (MSK) is very similar to metacognitive regulation interventions that have been the focus of this review. The development of MSK in terms of the knowledge component in the study also pinpoints the same metacognitive awareness piece of my study. This critical aspect of metacognitive regulation intervention, however, is that, like metacognitive strategy knowledge, might be contingent on various external factors, such as gender, socio-economic status, self-efficacy, learning motivation, etc. For this reason, this study will include assessment of these variables in conjunction with its assessment of metacognitive knowledge, metacognitive regulation, and the effectiveness of a given metacognitive regulation intervention.

According to *Student Perception of Metacognitive Activities in Entry-Level Science Courses,* an October 2014 study of metacognition-influenced in-course instruction, researchers reveal the implication that, "recognizing metacognition as a valuable learning tool for both instructors and students is a long process." The study concludes, "Exposure to metacognitive activities needs to be implemented throughout curriculum to maximize effectiveness for students, at the same time, authentic activities that enhance metacognitive skills require time to prepare, plan and implement" (Sandall *et al.*, 2014). This realization suggests that this study of metacognitive regulation interventions might not be entirely effective in transforming student metacognitive abilities. It is the purpose of this study, however, to investigate the current and post-intervention perceptions of 100-level math and science students in order to accurately gauge the need for metacognitive awareness in DePauw classrooms.

While there are numerous strategies that research suggests are "effective" in metacognitive regulation, the focus of this study will be to assess current metacognitive knowledge of students in 100-level math and science courses, the effectiveness of three chosen interventions, and the post-intervention perception of students, which will assess their metacognitive knowledge at the end of the trial period. Metacognitive regulation interventions are not as commonly discussed in literature, as are in-class assignments and practices, which seek to encourage metacognition.

According to McGuire, Cook, and Kennedy's study, *Effect of Teaching Metacognitive Learning Strategies on Performance in General Chemistry Courses,* it is recommended for the first course examination assessing metacognition to be administered as early as possible. For this reason, the researcher will administer a pre-intervention survey during the first week of classes. A post-intervention survey will be administered at a later date, prior to the conclusion of the semester in order to assess student transformation during the semester.

The researcher will assess three different methods of intervention in this study by analyzing student reports and perceptions of effectiveness and knowledge of metacognition/metacognition regulation strategies both before and after intervention.[4] The interventions to be evaluated in this study, as chosen by the researcher, and the support for each intervention are as follows:

Intervention 1: How-to Metacognition Guide

Similar to the style of study guide and cliff notes, this intervention will provide students with quick facts on metacognition and the ways in which they can employ metacognitive

[4] From research of the effectiveness of these interventions, the researcher will construct a metacognitive regulation intervention implementation plan for the science literacy course committee at DePauw University.

regulation in their own learning processes. This guide, made by the researcher, will take the form of a text-based concept map, which will explain the idea and connections between learning, metacognitive knowledge, metacognitive regulation and strategy. It will assess if definitions and connections of this information are enough to effectively change student metacognitive regulation strategies, knowledge of cognition, and learning/studying habits. The success of this intervention is dependent on the student's willingness to read the guide and ability to interpret/use the material in a way that is individually effective.

Intervention 2: Metacognition Written Resource – Article

Drawn from the researcher's personal insight of metacognitive knowledge-building, this intervention will take the form of a written resource/article which discusses metacognition, metacognitive regulation strategies, and how to employ metacognition to enhance student learning and knowledge. This intervention, taken from an educational psychology textbook, will assess if reading an article about metacognition/metacognitive regulation would be enough to effectively change student metacognitive regulation strategies, knowledge of cognition, and learning/studying habits. This intervention is contingent on the student's willingness to read the article and ability to interpret/use the material in a way that is individually effective.

Intervention 3: Metacognitive Regulation Consultation Interview

Meeting face-to-face with the researcher, the consultation interview provides students with a verbal narrative of discovering metacognition and the possibility of regulating the learning process. Followed by five questions that encourage the student to think of the narrative in regards to his or her own experiences, the consultation is the most direct way to truly target a student's awareness of his or her metacognition. It is also the seemingly most personal way to discuss what metacognition is, as it allows the student to ask questions and to verbally assess his or her

metacognition aloud. This intervention relies on the student's willingness to sign up for an interview, attend the interview and interpretation of the interview in a way that is individually effective.

Conclusion

Through discussion of the definitions of metacognition, the history of metacognitive regulation research, the relationship between metacognition and science learning, and the importance of metacognitive regulation (and intervention types of this study), this literature review outlines the overall goal of this study: to assess the effectiveness of various metacognitive regulation interventions in introductory math and science courses at DePauw University. While this study will only be representative of DePauw students, and will only assess three chosen interventions, it is the hope of the researcher that further knowledge of metacognitive regulation interventions will positively impact DePauw's science literacy course, future students, and student learning overall.

4. RESEARCH METHODOLOGY AND DESIGN

Methods

Using two hard copy surveys that employ both quantitative (Likert scale, multiple choice, etc.) and qualitative (short answer, etc.) questioning, I prepared two separate IRB submissions, informed consent forms, and surveys for participants. The two surveys are a part of a longitudinal study method to reveal change over time for a particular population of DePauw students (enrolled in introductory science and math courses). The first survey (pre-intervention) collected information in regards to student knowledge of metacognition, their own cognitive processes, and study habits. [5] Professors were given an instruction sheet as well as two weeks to

[5] See Appendix 1.1

administer the survey.[6] An intervention type of "How-to Sheet," "Article," "Interview," or "No Intervention," was randomly assigned to each participating class. The second survey (post-intervention) collected information in regards to student knowledge of metacognition, their own cognitive processes, and study habit as well, but also assessed any changes (positive, negative, or neutral) that occurred during the intervention process. [7] Professors were given an instruction sheet as well as two weeks to administer the survey.[8] Both surveys also collect information in regards to student demographics. During the data analysis process, student perception(s) of intervention effectiveness, as well as assessed levels of metacognitive regulation/awareness will be analyzed to assess which intervention(s) was most effective.

Intervention 1: How-to Metacognition Guide[9]

Intervention 1 employed a metacognition and metacognitive regulation "fact sheet," which allowed students to engage with metacognitive regulation in a "how to" format. This intervention is supported through the idea that a quick and to the point information set might be successful in enhancing metacognitive regulation awareness and ability. While this intervention did not specifically focus on student motivation, an aspect of student motivation in taking the time to read this resource will be taken into account during data analysis.

Intervention 2: Metacognition Written Resource – Article[10]

Intervention 2 employed a metacognition and metacognitive regulation focused work of literature from a textbook. This piece was directed towards a universal audience and was left up to the interpretation of the individual student in that it was not formally discussed in class. This

[6] See Appendix 1.3
[7] See Appendix 3.1
[8] See Appendix 3.3
[9] See Appendix 2.1
[10] See Appendix 2.2

intervention is supported through the idea that individual metacognitive regulation is contingent on and individual understanding and individual bringing to awareness of this ability. While this intervention did not specifically focus on student motivation, an aspect of student motivation in taking the time to read this resource will be taken into account during data analysis.

Intervention 3: Metacognitive Regulation Consultation Interview[11]

Intervention 3 will employ a metacognitive and metacognitive regulation consultation interview outside of the classroom. In order to receive Intervention 3 distinction, participating students must have signed up and attended the interview with the researcher. This fifteen-minute interview was conducted by the researcher and utilized the strategy of verbally explaining metacognition strategies through a student narrative of discovering metacognitive regulation.

Control Group: No Intervention

A control group was utilized. This distinction will also represent any student who was not asked to participate in Intervention 1, 2, or 3, and will also include any student who did not attend the Intervention 3 meeting outside of class (or any student who indicates that they did not participate with any of the interventions). Three interventions differing in type, but similar in focus allowed this study to gauge which of the three is most effective, and whether results from any of the interventions differs from that of the non-intervention (control) group.

Control Group: No Interview

Participants who did not participate in their assigned intervention that was the interview, were treated as a part of the control group as well because they did not actually receive their intervention. This allowed the researcher to get a true gauge on student perception, even if students were not able to attend their interview.

[11] See Appendix 2.3

No First Survey

All participants were given the opportunity to take the pre-intervention and post-intervention survey, regardless of their assigned intervention or previous participation in the study. A small amount of participants chose to participate in the post-intervention survey but did not have a matching survey showing participation in the pre-intervention survey. These participants were placed in the No First Survey group and were treated as though they did not receive an intervention.

Data Collection

This survey was distributed to all participants in packet form. The first page of the packet included an informed consent agreement for all participants. The first packet (Metacognition Survey 1) included the pre-intervention survey and was labeled with a student ID number unique to the survey (ID numbers were constructed based on the intervention type and course, but have no correlation to the students' name). When pre-intervention surveys were completed, faculty members instructed students to place their completed survey in the course envelope. Surveys were kept inside these envelopes and returned to the researcher, but were kept in a confidential location until the post-intervention surveys were completed. The second packet included the post-intervention survey and was administered in the same fashion as the pre-intervention surveys. Once the final survey had been completed, the faculty members instructed students to place their completed survey in the course envelope. Survey informed consent pages were then matched with the consent pages from the first survey. This ensured student confidentiality, while allowing the pre and post-intervention surveys to be analyzed in conjunction with each other. Once all surveys in a classroom have been completed and the data has been analyzed, the instructor will distribute an electronic de-briefing sheet to students, providing the necessary

contact information for the survey and other information. Both surveys and the consultation interview required students to agree and sign an informed consent agreement.[12]

Data Sources

The data for this study will be purely based on student perception and opinions. Because there is no accurate way to test the level of a students' metacognition, or the extent to which they utilize metacognitive regulation (or its effectiveness), this method is best suited for analysis of the type of intervention that could potentially be used in future courses. These data sources will allow the researcher a greater insight into changes of metacognitive regulation and awareness when various interventions are employed. Outside of the quantitative data (Likert scale, multiple choice, etc.) and qualitative (short answer, etc.) questions on the survey, student interviews were transcribed and used as quantitative data. Some short answer questions were also coded and quantified in order to reveal trends in student answers and to more adequately assess the intervention(s) effectiveness.

Participants

For the purpose of this study, the researcher chose to focus on 100-level math and science courses in departments that will potentially participate in a 100-level comprehensive science literacy course next year at DePauw. Participation in this study was open to all students enrolled in these courses and was contingent upon allowance to participate by according faculty members teaching their course. Because this study does not immediately focus on demographics, the 100-level math and science course distinction was the only requirement for participation. The demographics of participants, however, were assessed in both surveys. Participants and study administrators were not financially compensated for participation in this study.

[12] See Appendices 1.2, 2.4, and 3.2

Research Timeline/Design

The following timeline gives an estimate as to when each research step occurred/will occur. The descriptions in this timeline outline the research process in chronological order, but adjustments and amendments were made accordingly.

November/December 2014 – Appropriate IRB forms were completed.. Intervention materials were also submitted and amended appropriately. Communications and conversations between the science literacy course committee, as well as all faculty members of affected departments were approached regarding course participation in the study. Additional forms, such as documentation of informed consent, were also created so to adequately prepare for future stages in the study's process. On November 14th and 15th, two funding proposals, the J. William and Katherine C. Asher Endowed Research Fund for Psychology and the J. William Asher and Dorothy A. Asher Fund in the Social Sciences, were submitted. On December 2nd, information was sent to all seven math and science department chairs via email to inform them of the study, its purposes, and intended methods. Six of seven department chairs responded (all except Geoscience), giving support for the researcher to contact their introductory science course faculty for the spring semester. On December 4th, information regarding the study, its purposes, and intended methods was sent to twenty-eight faculty members who were documented in the spring course listing (on eservices) to be teaching a 100-level math or science course in the designated departments. Confirmations from faculty members in regards to participation in the study revealed 12 faculty members with 17 100-level math and science courses would participate in the study.[13]

[13] See Appendix 4.2

January 2015 – The IRB proposal for the first survey was submitted on January 24th. Preparations for the pre-intervention survey: copies of materials, communication with participating faculty, and funding reimbursement. Course numbers and specific first day of course time information was obtained so to adequately prepare for implementation of the first survey. Envelopes were also constructed to make survey delivery and administration run smoothly.

Late January/February 2015 – IRB approval for the first survey was received on February 1st. Pre-intervention surveys were administered during the first 10-15 minutes of participating courses during the first two weeks of class (whenever it was convenient for the faculty member). The instructor to participate did not mandate students to participate. Completed surveys were collected with consent forms as a title and students were informed of the metacognitive regulation intervention assigned to their course by random. One fourth of the courses will remain a control group, while one fourth will be assigned to each of the three interventions respectively. The faculty member distributed materials for the assigned intervention. After all the surveys were collected, they were given an ID number and manually entered into a spreadsheet for analysis.[14] Post-intervention survey preparation began and the IRB for the second survey was submitted on February 17th and was approved on February 18th. Interviews for Intervention 3 were conducted using a narrative sheet and five questions. Students were sent 1 reminder email of their interview and were given the opportunity to reschedule if necessary. 26 student interviews were successfully conducted and will be transcribed by the researcher.

March 2015 – Post-intervention surveys were administered during the first 10-15 minutes of participating courses during the last two weeks of class before Spring Break (whenever it was

[14] See Appendix 4.1 and 4.3

convenient for the faculty member). Students were not mandated to participate, even if they participated in the first survey. Students who did not complete the first survey were also given the opportunity to participate in the second survey; however, the data from their answers will be kept separate from the students who completed the full survey process. Post-intervention surveys were collected (in the same fashion as pre-intervention surveys) and will be manually entered into a spreadsheet for analysis.

April 2015 – Metacognitive regulation interventions will be graded through analysis of student responses in the pre- and post- surveys. Effectiveness will be weighted on post-intervention surveys and overall perception and understanding of metacognitive strategies by students in each. Three digit numbers will track student identification; student consent forms will be separated from the surveys once both surveys are completed. Data will be analyzed.

May 2015 – Final analysis, poster presentation, and presentation at applicable symposiums will proceed. A final report of study findings will be presented to the committee currently in process of constructing a general science course at DePauw and a highlighted version of the study will be presented to all departments and faculty involved in the study. Findings and data will also be published or distributed as needed, keeping student confidentiality as the top priority.

5. DATA MANAGEMENT AND DATA ANALYSIS

Data Input

Once both surveys were administered and collected, answers to each question were entered into an Excel spreadsheet chart that was set up to display percentages of how questions were answered, categorized by intervention type or lack thereof[15]. Surveys were kept in the manila envelopes used for administration until data was inputted and informed consent contracts

[15] See Appendix 7.1

were separated from each survey packet. Student surveys were linked using matching informed consent forms and the numbering system (0-199 – Interview, 200-399 – Handout, 400-599 – Article, 600-699 – No Intervention/No Interview, 700-799 – No first survey). To preview initial data correlations, the researcher used a 1-5 numbering system, assigning each number to the appropriate Likert scale correlation (1 – Strongly Agree, 2 – Agree, 3 – Neutral, 4 – Disagree, 5 – Strongly Disagree). Inputting data from pre-intervention and post-intervention surveys in the same data collection document also allowed analysis of the overall change for students in each intervention group from the pre-survey stage, to the post-survey stage. This quantitatively driven analysis will help to relieve this aspect of the study from researcher bias. Statistical significance was also assessed using Excel formulas and color-coding in an electronic format (Red – not significant, Yellow, etc.)[16].

Additionally, the researcher is able to look individually at each pre and post-intervention survey in order to assess individual student growth or lack thereof. Growth or effectiveness of each intervention will be rated on a 1 to 5 scale, with each rating described by a specific set of qualifications. All qualifications and coding definitions were compiled in a Data Guide[17]. This additional analysis allowed the effectiveness of each intervention to be gauged by the researcher. It also allowed for qualitative perceptions and answers to be taken into account in analysis of the data. Additional data analysis could include demographics to be taken into account. While this study was not demographic-focused, this aspect of data analysis could potentially be beneficial for future study and research of this topic. Taking demographics into account is also important for acknowledging student differences and learning differences.

[16] Will be added.
[17] See Appendix 6.1

Recorded interviews were titled according to the number assigned to the students' survey number. Additional informed consent forms were used to match student surveys with the interview and only numbers were used to identify interview audio files. Transcripts from recorded interviews were typed and saved in an electronic document[18]. Quotes from these interviews were used by the researcher to analyze student metacognition regulation, metacognitive awareness, and metacognition use, and the interviews as a whole were ranked on a 1 to 5 scale, using the same specific set of qualifications used by the researcher in analysis of cumulative survey analysis. All recorded interviews were saved to two audio CDs.

Data Coding

Qualitative answers were then coded using a lettering system (A, B, C, etc.) that coded answers according to applicability to certain themes (Studying in the Library, Reading the Textbook, Using Flashcards/Notecards, etc.). This grounded coding method allowed the researcher to put aside prejudices, presuppositions and previous knowledge of the subject area and concentrate instead on finding themes in student study habits (IA Q1, IA Q2, and IA Q3). This method of coding was also used in analyzing student comments to survey sections and student responses to intervention effectiveness (IB Comments, IC Comments, ID Comments, IIC Q2, IID Comments, IIE Comments, and IIF Comments). A priori coding will be used in analyzing student definitions of metacognition based on the researcher's definition, pre-existing theories/definitions of metacognition, and answers proven sufficient by the researcher's discretion (IIC, Q1 and IIC Q3). All coded questions will be presented in a quantitative format as well as include a section of "Notable Student Answers" that will provide student quotes and demographic information (Current class, Intervention, Year, Major, Sex).

[18] See Appendix 2.5

Data Management

Data management consisted of filing paper surveys by classes (using envelopes) and numbering surveys and interviews using a number system (described above). If at any point survey packets were not in the possession of the researcher, they were concealed inside a large envelope. The researcher conducted distribution of survey packets in envelopes via in-person delivery. Once students completed their surveys, they were placed back inside this envelope and either sent through campus mail or personally picked up by the researcher. All data and forms pertaining to this study were kept in a "Metacognition Study" folder on the researcher's computer. Excel spreadsheets and audio files used in data collection and analysis were also kept in this folder. After matching informed consent forms and inputting data into the spreadsheet, all hardcopy surveys were shredded.

Final Participant Data

This study was conducted with the possibility for 17 courses (taught by 12 instructors) and a total of 389 participants (53 – Interviews, 153 – Handouts, 138 – Articles, 50 – No Intervention). For Metacognition Survey 1, a total of 274 participants completed the pre-intervention survey (25 – Interviews, 92 – Handouts, 92 – Articles, 42 – No Intervention/Control, 24 – No Interview/Control) with a participation percentage of 70.4% (47.2% – Interviews, 60.1% – Handouts, 66.7% – Articles, 84.0% – No Intervention/Control, 45.3% – No Interview/Control). For Metacognition Survey 2, a total of 211 participants completed the pre-intervention survey (21 – Interviews, 52 – Handouts, 70 – Articles, 35 – No Intervention/Control, 16 – No Interview/Control, 18 – No first survey) with a participation percentage of 47.8% (39.6% – Interviews, 34.0% – Handouts, 50.7% – Articles, 70.0% – No Intervention/Control, 30.2% – No

Interview/Control)[19]. Some students (in the Handout intervention) were given the option of taking the survey from the classroom. Students in the Article intervention group also received an updated electronic file of the article, as there was a mistake with some of the hardcopy articles at the printer. Some students in the interview intervention were not able to meet with the researcher, but continued on in the "No Interview/Control" group as though they were not assigned an intervention at all. Participation hypotheses include an increase of overall participation due to the in-class survey method and a decrease of overall participation due to the hardcopy nature of the survey, intervention as a "task" mentality (participants not wanting to read or do anything), and the timing of the two survey administration periods (Beginning of semester and right before Spring Break – could be stressful times for these students).

Data Analysis

Data charts were created (from the Excel spreadsheet) to show responses to each question and were formatted in a pie chart to express the percentages of a whole[20]. Each question, according to question type was analyzed and discussed. Data analysis was seemingly limitless, as the researcher had many options by which to analyze relationships between the two longitudinal surveys. Qualitative data was analyzed using the coding systems described and discretion of the researcher/interviewer. Additionally, observations were made from the data based on the likelihood that participants answered particular questions. These notes and analyses will be discussed informally in the research findings. Summaries of analyzed data will include charts and tables, but will also include discussions by the researcher and notes that discuss the meaning of the data for the study overall. Data will continue to be analyzed after the study is over, as there are numerous ways this data can be of use to the DePauw community.

[19] See Appendix 7.2
[20] See Appendix 7.4

6. FUNDING SOURCES AND PARTNERSHIPS

Funding Sources

J. William and Katherine C. Asher Endowed Fund for Psychology Research – Researcher requested $1,729.90; submitted on November 15, 2014; received $229.90 for use[21].

J. William Asher and Dorothy A. Asher Fund in the Social Sciences – Researcher requested $769.90; submitted on November 14, 2014; received $100.00 for use[22].

Personal Funds – Personal funds were used to cover the cost of a SPSS data analysis program because this fee was not covered by either grant received. No other personal funds were used.

Partnerships

Science Literacy Committee Support – Researcher received both input and support from committee members currently working on DePauw's 100-level science literacy course. Professors Michael Roberts, Jackie Roberts, and Pam Propsom have each individually discussed and advised this research. In addition, the committee viewed this research as a potential implementation and information source for its science literacy course curriculum.

Department Chair Support – Researcher emailed all department chairs of the appropriate math and science courses, and allowed adequate time for each chair to express support or disapproval of implementing this research in their respective 100-level courses. Chairs were informed that faculty members teaching 100-level courses in the spring will be contacted and asked to participate in this study. Support from six of seven department chairs was confirmed (all except Geoscience).

Faculty Support – Researcher emailed all faculty members of the appropriate 100-level math and science courses and allowed adequate time for each faculty member to agree or disagree to

[21] See Appendix 8.1
[22] See Appendix 8.2

participate with this research study. Support from twelve individual faculty members teaching seventeen 100-level math and science courses in the spring semester was obtained and received throughout the entire study.

7. RESEARCH FINDINGS

Student Study Habits

The surveys and interventions involved in this study aimed to collect and analyze information regarding students' general study habits, math and science study habits, and the likelihood of study habits to change due to metacognition regulation interventions. Questions IA Q1, IA Q2, and IA Q3 allowed students to report on their normal, most successful and least successful study habits respectively. Allowing students a short answer format left the possibility for data options unlimited and allowed students room to really think about their habits. Questions IB Q1-IB Q9 and IC Q1-IC Q6 used a Likert scale format to allow students to reveal how strongly they agreed or disagreed with the statements. It also allowed students to mark the frequency that they used the study habits that this study looked at. In addition to informing the study of the types of study habits that students have, these questions gave the researcher an insight into student awareness of study habits and student perceptions of their own study habits; both of which require metacognitive abilities to reflect on and discuss.

Normal Study Habits

Inquiries into the normal study habits of students revealed some indications of whether students had a grasp on their own study habits and whether they were aware of their own cognitive processes. Reflecting on study habits through short answer questions allowed students to divulge the extent to which they were aware of their study habits (and later the effectiveness of their chosen study habits). Many students used bullet points to indicate the various ways that

they normally study. Some student answers were very short while others were very thought out and seem to be very detailed. Normal study habits of flashcards, notecards, re-writing notes and re-doing test problems and quizzes represent the majority of ways that these science and math students choose to study. Additionally, many students reported that they prefer to study in groups or to seek out help from professors and other students. The data analyzed from this question allowed the researcher to analyze the extent to which each of these students are or are not aware of their own study habits and ways of learning[23].

Most Successful Study Habits

When asked about which study habits they have found to be most effective or most successful, many students reported that their most successful method was the same as the method they "normally" used. However, the majority of students reported different study habits that worked best for them. This revealed the metacognitive analysis students were going through as they decided between normal study habits and most successful habits. Additionally, analysis of this question allowed the researcher to analyze the extent to which each of these students are or are not aware of their own study habits and ways of learning[24].

Least Successful Study Habits

When asked about which study habits they have found to be least effective or least successful, many students reported that not being able to or having time to use the study habits that were most successful for them. However, the majority of students reported different study habits that worked the least well for them, many of which were varieties of habits they normally used. The most common least successful study habits were studying with a group and simply re-reading the textbook. This question and the short answers reported by students revealed the

[23] Appendix 7.4
[24] Appendix 7.4

metacognitive analysis students were going through as they decided between normal study habits, most successful habits, and least successful habits. Additionally, analysis of this question allowed the researcher to analyze the extent to which each of these students are or are not aware of their own study habits and ways of learning[25].

Study Habit Differentiation

One way of assessing whether students became more aware of regulating their metacognition or at least the ways they think about their own thinking is through study habit differentiation and comparing pre-intervention and post-intervention student perceptions. Pre-intervention study data revealed that 81% of students Strongly Agreed or Agreed that they studied differently for different courses. In the post-intervention study data, 55% of students reported that it was More True or Less False that they studied differently for different courses, while 42% of students reported that the extent to which they studied differently for different courses was the same as before the intervention. This data allowed the researcher to see a change in metacognition, or at least in thinking about study habits, which could reflect a change in metacognition regulation on the part of the individual students. More specifically, pre-intervention data revealed that 65% of students studied differently for math and science courses, while 49% of students reported it was More True or Less False that they studied differently for math and science courses post-intervention. Additionally, 39% of students in the post-intervention survey reported that they studied for math and science courses differently to the same extent that they did before the intervention. This general increase in studying differently and studying differently for math and science classes reveals a change in students overall that might be the result of the metacognition regulation interventions that were tested in this study. It

[25] Appendix 7.4

might also be the case that this data was the result of students getting into the middle of the semester and diversifying their study habits. Either way, there are many benefits from students even being open to and aware that they study in different ways. This alone sets up the path for metacognition regulation and increased metacognitive awareness.

Study Methods

Of the study methods asked about in the first survey, Keyword, followed by Method of Loci were reported to be the most used by students. Surprisingly, Rhymes, Acrostics and Acronyms were not used as much by students. Keywords, a tactic associated with memorization, allow students to use one word to learn a phrase or another piece of information. Method of Loci is a strategy more associated with metacognitive ability and introspection, allowing students a more abstract way of knowing and learning. Some students, however, did not remember or could not indicate whether they had used the study methods discussed. They were, however, very diverse in their answers and most students did not use the study methods the same amount. Data analyzing these study methods allowed the researcher to analyze the extent to which each of these students are or are not aware of their own study habits and ways of learning[26].

Handout – "How to"

The handout intervention made by the researcher was meant to give the students a "Cliff Notes" version of metacognition, what it is, and how it can be regulated. Students were expected to read the handout after the survey, however, as the data revealed, many of the students did not read the handout, did not take advantage of it, and did not remember receiving it. Additionally, it is not clear whether every single student actually received an intervention, even though it was included in the packets and instructions were given to instructors. Post-Intervention survey data

[26] Appendix 7.4

allowed the researcher to analyze the effectiveness of this intervention, as well as ways that the student participants thought the intervention should be improved.

Effectiveness of Intervention

The data revealed that only 26 of 52 students reported the correct intervention/receiving the handout as an intervention. Many of the students who said the intervention was effective reported that they previously had no knowledge of metacognition so the handout explained it to them. Others said that they liked the shortness of the handout and thought it was effective because of that. Regardless of student perceptions, 71.2% of the students in this intervention were able to provide a satisfactory personal definition of metacognition in the post-intervention survey. This was after only 14% of students in the study reported being familiar with metacognition in the post-intervention survey. Overall, this intervention was the third most effective of the three because most of the students did not read it and did not take advantage of it.

Suggestions to Improve

Many of the students recommended that this intervention be made more memorable. They claimed that they didn't even remember getting it, therefore, they were not as likely to take full advantage of it. Some students even mentioned that they would have liked to have more examples of ways to increase their own awareness of and regulation of metacognition. What is interesting, however, is that students in this intervention were the most likely not to take advantage of their intervention, even though it was indeed the shortest.

Article

The article intervention found in a textbook by the researcher was meant to give the students a detailed, written version of metacognition, what it is, and how it can be regulated. Students were expected to read the 10-page article after the survey, however, as the data

revealed, many of the students did not read the entire article, did not take advantage of it, and did not find it as giving examples of metacognition. Additionally, it is not clear whether every single student actually received the intervention, even though it was included in the packets and instructions were given to instructors. Post-Intervention survey data allowed the researcher to analyze the effectiveness of this intervention, as well as ways that the student participants thought the intervention should be improved.

Effectiveness of Intervention

The data revealed that all 70 students reported the correct intervention/receiving the handout as an intervention. Many of the students who said the intervention was effective reported that they previously had no knowledge of metacognition so the article gave them a foundation for understanding metacognition and the various study habits associated with cognitive processes and learning. Regardless of student perceptions, 60.0% of the students in this intervention were able to provide a satisfactory personal definition of metacognition in the post-intervention survey. This was after only 14% of students in the study reported being familiar with metacognition in the post-intervention survey. Overall, this intervention was the second most effective of the three because most of the students did not read the entire article and did not take advantage of it.

Suggestions to Improve

Many of the students recommended that this intervention be made shorter or for the researcher to provide a “Spark Notes,” versions. They claimed that they didn’t have time to read the entire article and needed incentive to read it outside of their regular course material. Additionally, students said they would have liked to have more examples of metacognition so to learn how to implement it better. What is interesting, however, is that students in this

intervention were the more likely to take advantage of their intervention than their Handout counterparts, but less likely than their interview counterparts. This is probably due to the length of the article.

Interview Intervention

The interview intervention written by the researcher was meant to allow students to verbally discuss their own metacognition after hearing a comprehensive student narrative of struggling with math and science at DePauw. It also focused on metacognition, what it is, and how it can be regulated in the math and sciences, differently than other courses. Students were expected to sign up for and attend the interview, however, as the data revealed, many of the students did not read attend their interview, resulting in an increased number of control group individuals. While all of the students remembered their interview, many of them did not see the format as being a good way to talk about metacognition, would have liked more time to think about the questions, and would have liked more interaction and intervention by the researcher in terms of analyzing their answers for them. Post-Intervention survey data allowed the researcher to analyze the effectiveness of this intervention, as well as ways that the student participants thought the intervention should be improved.

Effectiveness of Intervention

The data revealed that all 21 students reported the correct intervention/receiving the handout as an intervention; 4 did not take the post-intervention survey. Many of the students who said the intervention was effective reported that they liked getting the chance to talk to someone about their mental processes and ways of learning. Others said that they had never thought or knew they could think about their mental processes and cognition in the way that the researcher's questions led them to. Regardless of student perceptions, 100% of the students in this

intervention were able to provide a satisfactory personal definition of metacognition in the post-intervention survey. This was after only 14% of students in the study reported being familiar with metacognition in the post-intervention survey. Overall, this intervention was the most effective of the three because most of the students thought that the intervention was worth their time. They did, however, have many critiques of this intervention style and type.

Suggestions to Improve

Many of the students recommended that this intervention have a component of analysis in which the researcher would discuss and analyze what the interviewee had said. They claimed that the intervention simply had them discuss their own thinking and did not change anything about their learning and understanding. Some students even mentioned that they would have liked to have more examples of ways and methods to increase their own awareness of and regulation of metacognition. What is interesting, however, is that the most descriptive and out-of-the-box data was collected from these interviews.

No Intervention/Control (Including No Interview/Control)

The participants who did not receive an intervention at all and only received both surveys were classified as the control group. Participants who did not attend their interview, were also placed in this category, as only 25 of the possible 60 participants actually attended the interview that they signed up for. This did, however, make the interview data more manageable for the researcher. Most of these participants remembered that they did not receive an intervention, but also reported neutral for all of the questions following about effectiveness. Post-Intervention survey data allowed the researcher to analyze the effectiveness of lack of intervention, as well as ways that the student participants described what an intervention should be metacognition regulation.

Effectiveness of Intervention

Most of the students commented that their intervention was not effective because they did not receive an intervention. This was not reflected through the data, however, because many students reported being "Neutral" form many of the questions that addressed intervention effectiveness. Additionally, many of the students suggested that any intervention would be more helpful than no intervention. Some even suggested a handout or some more information about metacognition so that they could more fully understand it. Regardless of student perceptions, 44.1% of the students in this intervention were able to provide a satisfactory personal definition of metacognition in the post-intervention survey. Only 23.2% of students who did not fill out the first survey, however, were able to provide a satisfactory personal definition of metacognition in the post-intervention survey. This was after only 14% of students in the study reported being familiar with metacognition in the post-intervention survey.

Awareness/Knowledge of Metacognition

Data from the pre-intervention survey revealed that only 14% of students were Very Familiar or Familiar with Metacognition. The post-intervention survey, however, indicated that 59% of students could provide a satisfactory definition of metacognition. A satisfactory definition of metacognition consisted of hitting on one or more of the topics (Brain, Thinking, Learning, etc.) in the same way that the study's definition did. The change of 67% of students being Vaguely Familiar or Never Heard of It [Metacognition] demonstrates the influence of not only the tested interventions, but of the survey itself. As discussed in the analysis of each intervention, the percentage of students in each intervention able to provide a satisfactory personal definition of metacognition varies by intervention, however, all percentages for students able to provide a satisfactory personal definition are higher for the various interventions

(including that of No Intervention/No Interview) than for the students who only completed the post-intervention survey. This allowed the researcher to semi-conclude that the survey did more good than harm in terms of raising awareness for metacognition and increasing the likelihood of metacognition regulation on an individual level.

Agreement with Definition (pre vs. post)

Restating the definition of metacognition used by this study, metacognition is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." Pre-intervention data revealed that 74% of students Strongly Agreed or Agreed with the part of the study's definition that addressed understanding one's own thinking processes. The post-intervention survey confirmed this agreement in that 73% of students Strongly or Agreed with the same statement. Additionally, pre-intervention data reveled that 80% of students Strongly Agreed or Agreed that they could control their own thinking processes, while only 58% of students reported this post-intervention. The similar percentages of the first part of the definition, understanding one's thinking processes, suggests that students do have a firm understanding of the way they think in a simple sense (i.e. knowing which study method works best for them). However, the decrease of student reports of being able to control their thinking process might be due to the idea that they now question whether they can truly control their own thinking processes in increasingly complicated sense (i.e. knowing which study method to use for a task). This data is interesting because it suggests that even though students initially believe that they have control over their thinking processes, that forcing them to reevaluate this control might give them reason to question the amount of control they do have in these processes. Regardless of the data, analyzing these questions allowed the researcher to learn more about student perceptions in terms of metacognition and metacognition regulation.

Personal Definitions of Metacognition

After coding post-intervention data from question IIC Q3, the researcher analyzed data regarding students' personal definitions of metacognition. 4% of students discussed studying in their definition in terms of knowing how to change or alter their study habits to best fit their personal learning styles or cognitive processes. 13% of students discussed a connection to learning in this way, and 21% of students discussed a connection to thinking and/or thinking about their own thinking. 6% of students offered a definition that included both the awareness and regulation aspects of metacognition, while 4% discussed the brain and how metacognition works for and through it. 10% of students reported a definition other than the coded categories described, however, those student definitions were still within the confines of the study's definition of metacognition in some way. 42% of students answered, "I don't know," left the space blank or did not have a satisfactory personal definition of metacognition. While metacognition is different and unique for each individual, it is important that students have an accurate understanding of metacognition so to increase their personal awareness and individual metacognition regulation.

Agreement with "Thinking Quotes"

While asking students seemingly random quotes might seem unorthodox, this section of the post-intervention survey helped to unpack the students' true awareness and understanding of metacognition and the ways in which learning occurs. Using metacognitively-focused quotes and phrases from famous philosophers and authors, the researcher was able to ask participants the extent to which the quote applied to them personally. This was an attempt to capture the student's perception of their own metacognition, as well as the ways in which they view thinking and learning. 81%, the highest percentage of agreement, of students Agreed in some way that the

statement, “To read without reflecting is like eating without digesting” applied to them. This indicated to the researcher the majority of the students felt that reflecting and actually understanding material is better than just reading it and that the only way to read effectively or healthily, is to also reflect on what you read. The statement that the second highest percentage of students Agreed with in some way (71%) was, “Students can learn to think better if schools concentrate on teaching them how to do so.” This data indicated to the researcher that students believe it is the schools responsibility to teach students how to learn and also that students in general must be taught how to learn effectively. This applies to the intervention focus of this study in that the students surveyed realize the benefits of metacognitive instruction for the purposes of teaching them about how to incorporate metacognition into their learning styles and study habits. 64% of students Agreed in some way that the statement, “To make an individual metacognitively aware is to ensure that the individual has learned how to learn,” applied to them. This indicated to the researcher that many of the students understood the importance of the survey and intervention testing. The post-intervention question presenting the quote, “I think therefore I am,” revealed that 61% of students Agreed in some way that the presence of thought or conscious thinking verified their being. This is important for this study because it shows that over half of the students see themselves as thinking beings and could also see themselves as metacognitively-thinking beings. The statement, “Cognitive strategies are used to help achieve a particular goal while metacognitive strategies are used to ensure the goal has been reached,” was Agreed with in some way by 47% of students. This data might reveal that these students understand metacognition as a goal rather than a one-time action. This is important for continued metacognitive regulation instruction in a classroom setting. The statement, “Imagination is more important than knowledge,” explained that students who agreed with this statement believe that

creativity and being able to think in unique ways was more important than "concrete" knowledge and facts. 39% of students found this particular statement to be applicable. This is important as metacognition is sometimes abstract and applies to the students' imaginations, and not just what they think knowledge is.

Demographics

To analyze the demographics of student participants, the researcher will use First Survey/Second Survey formatting to clarify the number of students in that category. 17/14 of the students who responded were in the class of 2015 (Senior status); 30/24 of the students who responded were in the class of 2016 (Junior status); 94/73 of the students who responded were in the class of 2017 (Sophomore status); and 133/100 of the students who responded were in the class 2018 (First-Year status). Approximately 145/130 of the students were math or science majors (Mathematics, Biology, Biochemistry, Chemistry, Psychology, Environmental Science, Geology, Physics, Computer Science, Kinesiology). 146/111 of the students identified as female; 123/95 of the students identified as male; 5/5 of the students identified as Other/Prefer not to respond. 106/82 of the students who responded reported having a GPA in the 4.0-3.5 range; 97/76 of the students who responded reported having a GPA in the 3.4-3.0 range; 46/35 of the students who responded reported having a GPA in the 2.99-2.5 range; 8/5 of the students who responded reported having a GPA 2.49-2.0; and 17/13 of the students who responded reported having a GPA of Other/Prefer not to answer. 2/1 of the students who responded identified as American Indian/Native American; 33/27 of the students who responded identified as Asian; 15/12 of the students who responded identified as Black/African American; 17/9 of the students who responded identified as Hispanic/Latino; 189/146 of the students who responded identified as White/Caucasian; 0/0 of the students who responded identified as Pacific Islander; 14/10 of

the students who responded identified as Other; and 8/6 of the students who responded identified as Prefer not to answer[27]. While the demographics were important for recognizing student diversity, there were no significant differences between student answers based on demographics. Future research with a larger participant population might reveal other discrepancies, however, there were not enough participants to concretely establish significant demographic differences.

8. DISCUSSION OF RESEARCH FINDINGS

Discussion

From the data collected from both pre-intervention and post-intervention surveys, as well as from student interviews, the researcher can make very few concrete conclusions in regards to the effectiveness of the three metacognition regulation interventions tested in this study. Limited by the number of students completing one, both, or none of the surveys, the researcher's findings are specific to this group of individuals and might not be generalizable to all undergraduate introductory math and science students. Additionally, post-intervention survey data from No Intervention/Control and No Interview/Control groups reflects an increased number of neutral answers due to the fact that students did not have an intervention to evaluate. Also, students answering only the post-intervention survey, contributed to the lack of a cohesive reading of the effectiveness of the three interventions.

While some of the hypotheses on participation have been discussed, it is also important to account for the instructors' error and student error in completing the survey, returning the survey to the proper envelope, and receiving the intervention material (if applicable). Some students did not received a full article intervention, as there was a mistake with printing services. Those students, however, all received a pdf version of the article via email shortly after taking the pre-

[27] See Appendix 7.3 (for percentages)

intervention survey. This error, however, could have resulted in decreased participation and reading of the article intervention. Additionally, some students who were in the interview intervention did not have time to be interviewed when the researcher was available. This decreased the amount of students that received that intervention, and while most of the interview interventions were effective, an increased number of interviews and correlating student data might reveal a different story. Acknowledging these limitations allowed the researcher to analyze existing data from a standpoint of relativism and critique.

Overall, this study of metacognition regulation interventions, a type of instruction that was named for the purposed of this study, has allowed the researcher to experience the process of authentic and meaningful research. Additionally, investigating three very different intervention methods has allowed for a curriculum-based approach for addressing metacognition regulation and awareness. While these interventions will never be 100% effective for all students, the data and results of this study will provide insight for future studies of metacognition. Additionally, the science and math-specific data will be beneficial to the DePauw Science Literacy Committee an hopefully instruct them on how to best incorporate metacognition and science thinking into their course curriculum.

Implications of Research

At DePauw

From experience, the researcher has realized some of the difficulties in the transition between high school and undergraduate science. More specifically, the researcher realized that there is sometimes a disconnect between what it is a student needs to learn for a DePauw science course, and how it is that the student should go about learning it. This study directly impacts DePauw University because it has the potential to provide increased math and science

thinking/learning, math and science major retention, and math and science course requirement options for current and future DePauw students. Students who normally would have begged for the "easiest science or math course to fill their graduation requirements" will hopefully enjoy a science literacy course in the future. But this new course itself, as well as all other DePauw science and math courses and students could greatly benefit from the implementation of metacognitive regulation interventions since indeed the researcher's work and methodology reveals a deficiency in DePauw students' metacognitive knowledge and regulation skills, holistically and individually.

This study will make not only a short-term impact on the students it introduces metacognition to, but could also make a long-term impact on any current or future student who takes a course which might benefit from the addition of an effective metacognitive regulation intervention. This educational impact could change the lives and career paths of many students simply by introducing them to a type of knowledge and cognitive process regulation that they did not previously know was possible. In addition to the impact this study will have on students, faculty members will be able to gain a better understanding of metacognitive regulation interventions and strategies for use in their classroom. All faculty members involved with this study or on the science literacy committee will have access to this data and information and will be given a copy of a shortened version of the results if they desire. Hopefully this information will provide them with more DePauw-specific information in regards to student study habits, awareness of metacognition and student perceptions of math and science learning.

Assessing Pedagogical Implications

Due to the potential impact of this study on the DePauw student and faculty population, as well as its potential ability to impact the University's overall success in science course

instruction and retention, this project is applicable to all academic fields. This applicability stems from the relationship between course instruction and student learning. It also proceeds from a mindset that every student is equal, and therefore, should be able to establish working and effective metacognitive strategies in their own mental processes. Additionally, this project addressed potential flaws in instructional methods in a field, which is disputably directed towards certain audiences of sex (male vs. female) and prior experience (high school course rigor or previous college courses). More specifically, this study highlighted the importance of establishing viable metacognitive regulation(s) in math and science course instruction so to allow access of science thinking, understanding, and application to a diverse population of undergraduates and potential science majors.

Assessing Implications for Participants

Due to the academic nature of this survey, there was a potential for miscommunication of intent, or misinterpretation of the given material. Students who might have misunderstood intervention material could have potentially alter their cognitive or learning processes in a way that is unfavorable for their academic performance. Because not every instruction method is most effective for all students, it is also important to simply realize the possibility of this implication(s). The researcher has provided for these implications by offering a de-brief/de-brief information and will make data and summary reports available to any and all parties that request this information. Participants as a whole will not be contacted again in regards to this study unless they have previously indicated wanting to be updated.

Conclusion

Addressing the over-arching question of this study, “Is metacognition regulation intervention(s) an effective implementation for undergraduate science course instruction?,” the

two-part survey and intervention sequence completed in the 2015 Spring semester at DePauw University reveals that while students might initially be unfamiliar with metacognition as a term, they are increasingly able to define it with personalized definitions and increasingly likely to be motivated to incorporate metacognition and metacognition regulation into their daily lives, study habits, and academic thinking. More specifically, this study shows that introductory math and science students think that metacognition is important. Working from this crucial information, the sub-question, "Is metacognition regulation intervention(s) in undergraduate science course instruction effective?," is also answered through this study's engagement of three interventions and post-intervention survey of effectiveness. Students who did not receive an intervention and also students who did not receive the pre-intervention survey were not as likely to understand metacognition in order to give a satisfactory personal definition. Additionally, student perceptions of effectiveness, while not universal, provide positive feedback for the three interventions, but also even more vital feedback on how these three interventions could be improved. This sub-question is answered: yes, metacognitive regulation intervention in undergraduate science course instruction is effective, however, some intervention types are more effective than others. Discussing this point, the second sub-question, "What types of metacognition regulation intervention(s) can/should be used in undergraduate science course instruction?," was answered in this study by the researcher's analysis of the data collected in the pre-intervention survey, interviews, and post-intervention surveys. This sub-question is answered: face-to-face interventions, such as an interview, were the most effective, however, there are ways in which this type of intervention can be expanded and improved. All of these questions provided a sound framework for an authentic study of metacognition regulation interventions at DePauw.

For these reasons, the main question of this study is answered: yes, metacognition regulation intervention is an effective implementation for undergraduate science course instruction, however, additional research needs to be conducted in order to maximize the effectiveness of this type of intervention. Additionally, this study suggests that face-to-face interventions are most effective, however, consistent follow-ups and direct application to math and science courses seems to be the most effective metacognition regulation intervention, according to this study.

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APPENDIX 1.1 **Metacognition Survey 1**

Part IA

Please write a short description of how you would normally go about studying for a test.

Please write a short description of a study method that works the ***most*** successfully for you.

Please write a short description of a study method that works the ***least*** successfully for you.

Part IB

Directions – Circle the answer that best reflects your personal position on the following statements.

1. I consider myself to be a math and science person.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

2. I consider myself to be a strong math and science student.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

3. I study differently for different types of courses (i.e. Science/Math, Humanities, etc.).

   Strongly Agree Agree Neutral Disagree Strongly Disagree

4. I study differently for different types of tests (i.e. essay, multiple choice, fill-in, etc.)

   Strongly Agree Agree Neutral Disagree Strongly Disagree

5. I study differently for math and science courses, specifically.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

6. I study differently for math and science tests, specifically.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

7. I struggle with deciding how to study.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

8. My study habits have changed since entering college.

Strongly Agree Agree Neutral Disagree Strongly Disagree

9. I will do well in this course because I know how to study for it.

Strongly Agree Agree Neutral Disagree Strongly Disagree

Part IB Comments (Please elaborate on any of your answers in this section):

Part IC

Directions – Circle the answer that best reflects your personal position on the following statements.

1. I think about how I think and learn.

Always Very Often Sometimes Rarely Never

2. I think about how my mind works.

Always Very Often Sometimes Rarely Never

3. I use the following strategy to study or learn:

Ex. Rhyme (i.e. to-be-remembered items of information are embedded in a rhyme)

Always Very Often Sometimes Rarely Never

Ex. Acronym (i.e. first letter from each to-be-remembered item is used to make a word)

Always Very Often Sometimes Rarely Never

Ex. Acrostic (i.e. first letter from to-be-remembered items are used to create a series of words/forms a sentence)

Always Very Often Sometimes Rarely Never

Ex. Method of loci (i.e. generate visual images of locations and pair with to-be-remembered items to memorize)

Always Very Often Sometimes Rarely Never

Ex. Keyword (i.e. create a visual image of a word which links to to-be-remembered item)

Always Very Often Sometimes Rarely Never

4. I study differently for math and science courses, specifically.

Always Very Often Sometimes Rarely Never

5. I study differently for math and science tests, specifically.

Always Very Often Sometimes Rarely Never

6. I struggle with deciding how to study for math and science courses and tests.

Always Very Often Sometimes Rarely Never

Part IC Comments (Please elaborate on any of your answers in this section):

Part ID

1. What is your level of familiarity with the term "Metacognition" *prior* to this survey?

Very Familiar Familiar Somewhat Familiar Vaguely Familiar Never heard of it

For the purpose of this study, the definition of "Metacognition" is **"the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes."**

Based on this definition, circle the answer that best reflects your personal position on the following statements.

2. I understand my own thinking processes; I know which study methods work best for me.

Strongly Agree Agree Neutral Disagree Strongly Disagree

3. I control my own thinking processes; I choose which study method(s) to use for a task.

Strongly Agree Agree Neutral Disagree Strongly Disagree

Part ID Comments (Please elaborate on any of your answers in this section):

Part II - Demographics

Graduation Year? 2015 2016 2017 2018 Other: _____

Academics? Major(s): _____

GPA Range: 4.0-3.5 3.49-3.0 2.99-2.5 2.49-2.0 Other/Prefer not to answer

How do you identify? Female Male Prefer not to respond

How do you describe yourself?

American Indian/Native American White/Caucasian

Asian Pacific Islander

Black/African American Other: _____

Hispanic/Latino Prefer not to answer

APPENDIX 1.2 **Metacognition Study Description and Informed Consent**

STUDY DESCRIPTION

The survey that you are being asked to participate in is a part of a senior research project conducted by Rachel Hanebutt. This project is being conducted as a part of Professor Eva Weisz's Education Senior Seminar course in the Education Department at DePauw University and has been designed through consultation with Professor Jamie Stockton. This two-part in-class survey will focus on undergraduate introductory science or math student thinking and study behavior/habits and will include the variable of an intervention, which has been assigned to your class and will occur between the two surveys. You will only be taking the first survey today. Your professor will inform you of your intervention assignment before participating. If you chose to participate in this survey you will be asked questions regarding your perceptions of your own thinking, your study habits and behaviors, and your demographic information. Each of the two in-class surveys in this study should take approximately 5-10 minutes to complete. Your class has been assigned one of the following intervention types and you are strongly encouraged to take advantage of this intervention.

Intervention Name	Description
Handout	A handout, which you are encouraged to read and use to your advantage this semester.
Article	An article, which you are encouraged to read and use to your advantage this semester.
Student Interview	An out of class student interview, which will take approximately 15 minutes.
No Intervention	Control group – only takes survey

When considering your participation in this study, we ask that you consider the following:

- Participation is completely voluntary and you may stop participating in this at any time without penalty.
- No risks are involved and there will be no monetary benefits from participation.
- The information in this study will be kept strictly confidential (no names recorded or used). Professors will not have access to participants' surveys, answers, or identities.
- The study has been approved by DePauw's Institutional Review Board to insure that the study conforms to ethical principles in the conduct of research with human subjects.
- At the conclusion of the experimental session, the experimenters will provide their phone numbers and email addresses and the phone number and email address of the faculty sponsor. This is to enable you to contact someone should questions or complaints arise.
- After **May 10, 2015** you may contact one of the following to receive a full description of the nature, purpose and results of this study.

Rachel Hanebutt
rachelhanebutt-2015@depauw.edu
812.630.5108

Dr. Jamie Stockton
jstockton@depauw.edu
765.658.4522

Dr. Eva Weisz
eweisz@depauw.edu
765.658.1043

INFORMED CONSENT

As a volunteer for this study, I, _____, the undersigned, verify that I am 18 years or over and have read and understood the conditions and rights listed above.

SIGNATURE: _____ DATE: _____

Please write the course name/number and the professor's name below.

COURSE: _____ PROFESSOR'S NAME: _____

APPENDIX 1.3 **Metacognition Study Instructions for Professors**

Thank you for participating in this two-part survey with intervention. This survey will take approximately 5-10 minutes for students to take and 15 minutes to completely administer. Your role as the instructor is to pass out the survey packets and to allow students to participate if they choose to do so. Each survey has an informed consent sheet with a description of the study. If the students have any questions regarding the study, its intentions, or the project as a whole, please feel free to direct them to any of the three contacts on the first page of the survey.

Each student who decides to participate must fill out and sign the informed consent (the first page of the survey). Then, students may choose to fill out the survey and provide demographic information. If a student does not feel comfortable answering a question on the survey, they are not obligated to do so. After students have completed their survey, please have them place the survey packet in the envelope I have provided to you. You may then return the envelope to me via campus mail (UB Box 5950) or email me and I can pick it up.

The following are instructions based on the intervention type listed on the front of your envelope. Please inform the students of your courses' intervention type before administering the survey:

Handout – After students have turned in their survey packet, please give them a copy of the Metacognition How-To Handout and encourage them to read and take advantage of the material.

Article – After students have turned in their survey packet, please give them a copy of the Metacognition Article and encourage them to read and take advantage of the material.

Interview – After students have turned in their survey packet, please ask and encourage them to sign up for a 15-minute time slot for interview. If there is not a time slot that fits with their schedule, please encourage them to contract me via email or phone (listed on the interview sheet). If students have questions about this interview, please assure them that it will be a short informative session and that they will not need to know any particular information for participation.

APPENDIX 2.1 **Metacognition How-to Sheet (Intervention 1)**

"Learning how to learn cannot be left to students.
It must be taught. (Gall *et al.*, 1990)"

Metacognition is the "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes."

Are you aware that there are different ways to study for different things? Your mind might work differently for different types of tasks, so studying the same way for every subject, including math and science might not be the best habit.

Metacognition is the active practice and awareness of understanding and controlling your own cognitive processes. This includes learning strategies and study habits. But it takes time, attention, and awareness for you to gain control of your own cognitive processes.

There are two types of learning tactics

- *Memory-directed tactics* – which contain techniques that help produce accurate storage and retrieval of information
- *Comprehension-directed tactics* – which contain techniques that aid in understanding-the meaning of ideas and their interrelationships

Strategies of learning and studying:

Mnemonic Devices – helps a learner transform or organize information to enhance its ability to be retrieved

- *Rhymes* - to-be-remembered items of information are embedded in a rhyme
    - Ex. Thirty days hath September, April, June, and November
- *Acronym* - first letter from each to-be-remembered item is used to make a word
    - Ex. HOMES (for names of Great Lakes – Huron, Ontario, Michigan, Erie, Superior)
- *Acrostic* - first letter from to-be-remembered items are used to create a series of words/forms a sentence
    - Ex. A Rat In The House May Eat The Ice Cream (To remember spelling of Arithmetic)
- *Method of loci* - generate visual images of locations and pair with to-be-remembered items to memorize
    - Ex. Use a chair to "place" and remember information, etc. (look around the room to study)
- *Keyword* - create a visual image of a word which links to to-be-remembered item
    - Ex. Spanish word pato (pronounced pot-o) means duck – imagine a duck with a pot on its head

Other Learning Strategies:

- *Self-Questioning* - helps students to better understand what they read and helps students to truly monitor their own comprehension. Self-questioning is one of the easiest ways students can access and control their metacognition.

Self-Questions you can ask yourself to engage metacognition:

- What is a new example of…?
- How would I use…to…?
- What would happen if…?
- What are the strengths and weaknesses of…?
- What do I already know about…?
- How does…tie in with what I learned before?
- Explain why…
- Explain how…
- How does…affect…?
- What is the meaning of…?
- Why is…important?
- What is the difference between…and…?
- How are…and…similar?
- What is the best…and why?
- What are some possible solutions to…?
- Compare…and…with regard to…
- How does…cause…?
- What do I think causes…?
- How do I know…?

Important Facts:

- Rote rehearsal is not very effective, but cumulative rehearsal, which involves rehearsing a small set of items for several repetitions, dropping the item at the top of the list and adding a new one, and so on, is highly effective because items to be remembered are given the category label and generate more easily.
- Handwriting notes during a lecture leads to better retention and comprehension and allows students to recall information when reviewing the notes post-lecture.
- Students need to be taught how to use learning tactics to make connections among ideas they know and new information. These learning tactics should be taught as a part of students' broader learning strategy.

Additional Resources:

http://education.purduecal.edu/Vockell/EdPsyBook/Edpsy7/edpsy7_meta.htm

https://teal.ed.gov/tealGuide/metacognitive

http://chronicle.com/article/MetacognitionStudent/130327/

****Take your own notes about your own Metacognitive skills and strategic learning tactics here****

APPENDIX 2.2 **Metacognition Article/Written Resource (Intervention 2)**

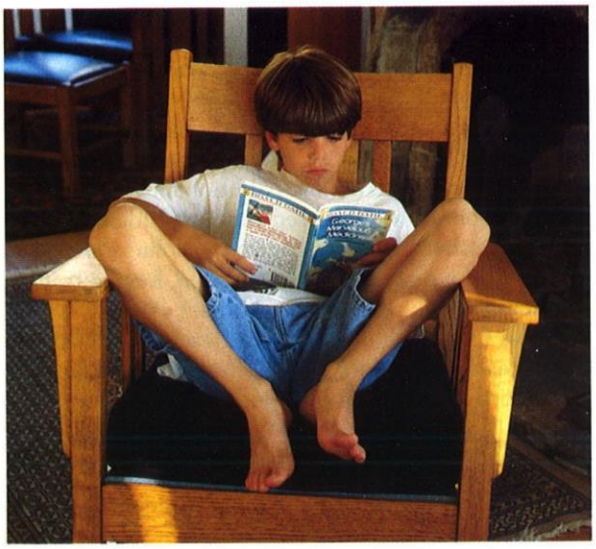
Metacognition

The discussion up to this point has focused on a general explanation of how people attend to, encode, store, and retrieve information. In a word, we have described some of the major aspects of thinking. During the past few decades, researchers have inquired into how much knowledge individuals have about their own thought processes and what significance this knowledge has for learning. The term that was coined to refer to how much we know of our own thought processes is metacognition. As we will see, it plays a very important role in learning.

THE NATURE AND IMPORTANCE OF METACOGNITION

The notion of metacognition was proposed by developmental psychologist John Flavell (1976) to explain why children of different ages deal with learning tasks in different ways. For example, when seven-year-olds are taught how to remember pairs of nouns using both a less effective technique (simply repeating the words) and a more effective technique (imagining the members of each pair doing something together), most of these children will use the less effective technique when given a new set of pairs to learn. Most ten-year-olds, however, will opt to use the more effective method (Kail, 1990). The explanation for this finding is that the seven-year-old has not had enough learning experiences to recognize that some problem-solving methods are better than others. To the younger child, one means is as good as another. This lack of metacognitive knowledge makes true strategic learning impossible for young children.

One way to grasp the essence of metacognition is to contrast it with cognition. The term *cognition* is used to describe the ways in which information is processed—that is, the ways it is attended to, recognized, encoded, stored in memory for various lengths of time, retrieved from storage, and used for one purpose or another. **Metacognition** refers to our knowledge about those operations and how they might best be used to achieve a learning goal. As Flavell put it:



Metacognition refers to the knowledge we have about how we learn. It is a key component of our ability to regulate our learning processes.

Metacognition: our own knowledge of how we think

> I am engaging in metacognition . . . if I notice that I am having more trouble learning A than B; if it strikes me that I should double-check C before accepting it as a fact; if it occurs to me that I had better scrutinize each and every alternative in any multiple-choice type task situation before deciding which is the best one; if I become aware that I am not sure what the experimenter really wants me to do; if I sense that I had better make a note of D because I may forget it; if I think to ask someone about E to see if I have it right. Such examples could be multiplied endlessly. (1976, p. 232)

Metacognition is obviously a very broad concept. It covers everything an individual can know that relates to how information is processed. To get a better grasp of this concept, you may want to use the three-part classification scheme that Flavell (1987) proposed: knowledge-of-person variables, task variables, and strategy variables. An example of knowledge-of-person variables is that one is good at learning verbal material but poor at learning mathematical material. Another example is knowing that information not rehearsed or encoded is quickly forgotten. An example of knowledge of task variables is that passages with long sentences and unfamiliar words are usually harder to understand than passages that are more simply written. An example of knowledge-of-strategy variables is knowing that one should skim through a text passage before reading it to determine its length and difficulty level.

Lev Vygotsky believed that children acquire metacognitive knowledge and skills most effectively through direct instruction, imitation, and social collaboration in the following way:

1. Children are told by more experienced and knowledgeable individuals what is true and what is false, what is right and what is wrong, how various things should and should not be done, and why. ("Jason, don't touch that stove. It's hot and will give you a painful burn if you touch it.")
2. As opportunities arise, children use this knowledge to regulate their own behavior (saying out loud, "Hot stove. Don't touch.") as well as the behavior of others. If you have ever seen young children play "House" or "School" and faithfully mimic the dictates of their parents or teacher, then you have seen this process at work.
3. Children regulate their own behavior through the use of inner speech.

Vygotsky's analysis strongly suggests that providing children with opportunities to regulate their own and others' behavior, as in peer tutoring, is an excellent way to help them increase their metacognitive knowledge and skills and to improve the quality of their learning. Later in this chapter, we describe one such program, reciprocal teaching. Programs like reciprocal teaching have produced high levels of learning, motivation, and transfer (Karpov & Haywood, 1998).

Recent research indicates significant differences in what younger and older children know about metacognition. What follows is a discussion of some of these differences.

Age Trends in Metacognition

Two reviews of research on metacognition (Duell, 1986; Kail, 1990) examined how students of different ages use memorization techniques and how well they understand what they are doing. Following are some of the key conclusions of the reviews:

- In terms of diagnosing task difficulty, most six-year-olds know that more familiar items are easier to remember than less familiar items and that a small set of items is easier to recall than a large set of items. What six-year-olds do not yet

realize is that the amount of information they can recall immediately after they study it is limited.

- Similar findings have been obtained for reading tasks. Most second graders know that interest, familiarity, and story length influence comprehension and recall. However, they are relatively unaware of the effect of how ideas are sequenced, the introductory and summary qualities of first and last paragraphs, and the relationship between reading goals and tactics. Sixth graders, by contrast, are much more aware of the effects of these variables on comprehension and recall.
- Most young children know very little about the role their own capabilities play in learning. For example, not until about nine years of age do most children realize that their recall right after they study something is limited. Consequently, children through the third grade usually overestimate how much they can store in and retrieve from short-term memory. One likely reason for this developmental difference is that younger children base their prediction on irrelevant personal characteristics (such as, "I'm pretty smart"), whereas older children focus more on relevant task characteristics.
- There are clear developmental differences in how well students understand the need to tailor learning tactics to task demands. For example, four- and six-year-old children in one study cited by Robert Kail (1990) did not alter how much time they spent studying a set of pictures when they were told that a recognition test would follow either three minutes later, one day later, or one week later. Eight-year-olds did use that information to allocate less or more study time to the task.
- In terms of monitoring the progress of learning, most children younger than seven or eight are not very proficient at determining when they know something well enough to pass a memory test. Also, most first graders typically don't know what they don't know. When given multiple opportunities to study and recall a lengthy set of pictures, six-year-olds chose to study pictures they had previously seen and recalled as well as ones they hadn't. Third graders, by contrast, focused on previously unseen pictures.

The general conclusion that emerges from these findings is that the youngest school-age children have only limited knowledge of how their cognitive processes work and when to use them. Consequently, primary grade children do not systematically analyze learning tasks, formulate plans for learning, use appropriate techniques of enhancing memory and comprehension, or monitor their progress because they do not (some would say cannot) understand the benefits of doing these things. But as children develop and gain more experience with increasingly complex academic tasks, they acquire a greater awareness of metacognitive knowledge and its relationship to classroom learning. In this process, teachers can assist their students and guide them toward maximum use of their metacognitive knowledge. To help you understand how, the next section will discuss learning tactics and strategies.

Insight into one's learning processes improves with age

Helping Students Become Strategic Learners

With some effort and planning, a teacher can make logically organized and relevant lessons. However, this is only half the battle because students must then attend to the information, encode it into long-term memory, and retrieve it when needed. Getting students to use the attention, encoding, and retrieval processes discussed in

the previous sections is not always easy. The sad fact is that most children and adults are inefficient learners (as evidenced, for example, by Bond, Miller, & Kennon, 1987; Brown, Campione, & Day, 1981; Covington, 1985; Davies, 1984; Selmes, 1987; Simpson, 1984; Winne & Jamieson-Noel, 2001). Their attempts at encoding rarely go beyond rote rehearsal (for example, rereading a textbook chapter), simple organizational schemes (outlining), and various cueing devices (underlining or highlighting). And although evidence exists that some students use different learning skills for different tasks (Hadwin, Winne, Stockley, Nesbit, & Woszczyna, 2001), most do not do so consistently or systematically.

One reason for this state of affairs is that students are rarely taught how to make the most of their cognitive capabilities. In one study, sixty-nine kindergarten through sixth-grade teachers gave strategy instruction only 9.5 percent of the time they were observed. Rationales for strategy use were given less than 1 percent of the time, and 10 percent of the teachers gave no strategy instructions at all. Moreover, the older the students were, the less likely they were to receive strategy instruction (Moely et al., 1992). A similar study of eleven middle school teachers eight years later produced the same findings. Teaching behaviors that reflected strategy instruction occurred only 9 percent of the time (Hamman, Berthelot, Saia, & Crowley, 2000).

Findings such as these are surprising, not to mention disappointing, since it is widely recognized that the amount of independent learning expected of students increases consistently from elementary school through high school and into college. The rest of this chapter will try to convince you that it need not be this way, at least for your students.

The Nature of Learning Tactics and Strategies

Strategy: plan to achieve a long-term goal

Tactic: specific technique that helps achieve immediate objective

A **learning strategy** is a general *plan* that a learner formulates for achieving a somewhat distant academic goal (like getting an A on the next exam). Like all other strategies, it specifies what will be done to achieve the goal, where it will be done, and when it will be done. A **learning tactic** is a specific *technique* (like a memory aid or a form of note taking) that a learner uses to accomplish an immediate objective (such as to understand the concepts in a textbook chapter and how they relate to one another).

As you can see, tactics have an integral connection to strategies. They are the learning tools that move you closer to your goal. Thus, they have to be chosen so as to be consistent with the goals of a strategy. If you had to recall verbatim the Preamble to the U.S. Constitution, for example, would you use a learning tactic that would help you understand the gist of each stanza or one that would allow for accurate and complete recall? It is surprising how often students fail to consider this point. Because understanding the different types and roles of tactics will help you better understand the process of strategy formulation, we will discuss tactics first.

Types of Tactics

Most learning tactics can be placed in one of two categories based on the tactic's primary purpose:

- *Memory-directed tactics,* which contain techniques that help produce accurate storage and retrieval of information
- *Comprehension-directed tactics,* which contain techniques that aid in understanding the meaning of ideas and their interrelationships (Levin, 1982)

Because of space limitations, we cannot discuss all the tactics in each category. Instead, we have chosen to discuss a few briefly that are either very popular with students or have been shown to be reasonably effective. The first two, rehearsal and mnemonic devices, are memory-directed tactics. Both can take several forms and are used by students of almost every age. The last two, self-questioning and note taking, are comprehension-directed tactics and are used frequently by students from the upper elementary grades through college.

Rehearsal The simplest form of rehearsal—rote rehearsal—is one of the earliest tactics to appear during childhood, and almost everyone uses it on occasion. It is not a particularly effective tactic for long-term storage and recall because it does not produce distinct encoding or good retrieval cues (although, as discussed earlier, it is a useful tactic for purposes of short-term memory). According to research reviewed by Kail (1990), most five- and six-year-olds do not rehearse at all. Seven-year-olds sometimes use the simplest form of rehearsal. By eight years of age, youngsters start to rehearse several items together as a set instead of rehearsing single pieces of information one at a time. A slightly more advanced version, *cumulative rehearsal*, involves rehearsing a small set of items for several repetitions, dropping the item at the top of the list and adding a new one, giving the set several repetitions, dropping the item at the head of the set and adding a new one, rehearsing the set, and so on.

Rote rehearsal not a very effective memory tactic

By early adolescence, rehearsal reflects the learner's growing awareness of the organizational properties of information. When given a list of randomly arranged words from familiar categories, thirteen-year-olds will group items by category to form rehearsal sets. This version of rehearsal is likely to be the most effective because of the implicit association between the category members and the more general category label. If at the time of recall the learner is given the category label or can generate it spontaneously, the probability of accurate recall of the category members increases significantly.

Mnemonic Devices A **mnemonic device** is a memory-directed tactic that helps a learner transform or organize information to enhance its retrievability. Such devices can be used to learn and remember individual items of information (a name, a fact, a date), sets of information (a list of names, a list of vocabulary definitions, a sequence of events), and ideas expressed in text. These devices range from simple, easy-to-learn techniques to somewhat complex systems that require a fair amount of practice. Because they incorporate visual and verbal forms of elaborative encoding, their effectiveness is due to the same factors that make imagery and category clustering successful: organization and meaningfulness.

Acronym: word made from first letters of items to be learned

Acrostic: sentence made up of words derived from first letters of items to be learned

Loci method: visualize items to be learned stored in specific locations

Keyword method: visually link pronunciation of foreign word to English translation

Although mnemonic devices have been described and practiced for over two thousand years, they were rarely made the object of scientific study until the 1960s (see Yates, 1966, for a detailed discussion of the history of mnemonics). Since that time, mnemonics have been frequently and intensively studied by researchers, and there are several reviews of mnemonics research (for example, Bellezza, 1981; Higbee, 1979; Pressley, Levin, & Delaney, 1982; Snowman, 1986). Table 8.1 provides descriptions, examples, and uses of five mnemonic devices: rhymes, acronyms, acrostics, the loci method, and the keyword method.

Why Mnemonic Devices Are Effective Mnemonic devices work so well because they enhance the encodability and retrievability of information. First, they provide a context (such as acronyms, sentences, mental walks) in which apparently unrelated items can be organized. Second, the meaningfulness of material to be learned is

Table 8.1 Five Types of Mnemonic Devices

Mnemonic	Description	Example	Uses
Rhyme	The items of information that one wants to recall are embedded in a rhyme that may range from one to several lines. A rhyme for recalling the names of the first 40 U.S. presidents, for example, contains 14 lines.	• Thirty days hath September, April, June, and November • Fiddlededum, fiddlededee, a ring around the moon is $\pi \times d$, If a hole in your sock you want repaired, Use the formula π r squared (to recall the formulas for circumference and area)	Recalling specific items of factual information
Acronym	The first letter from each to-be-remembered item is used to make a word. Often called the *first-letter mnemonic.*	• HOMES (for the names of the Great Lakes—Huron, Ontario, Michigan, Erie, Superior)	Recalling a short set of items, particularly abstract items, in random or serial order
Acrostic	The first letter from each to-be-remembered item is used to create a series of words that forms a sentence. The first letter of each word in the sentence corresponds to the first letters of the to-be-remembered items.	• Men Very Easily Make Jugs Serve Useful New Purposes (for the names of the 9 planets in our solar system—Mercury Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto) • A Rat In The House May Eat The Ice Cream (to recall the spelling of the word *arithmetic*)	Recalling items, particularly abstract ones, in random or serial order
Method of loci	Generate visual images of and memorize a set of well-known locations that form a natural series (such as the furniture in and the architectural features of the rooms of one's house). Second, generate images of the to-be-learned items (objects, events, or ideas), and place each in a separate location. Third, mentally walk through each location, retrieve each image from where it was placed, and decode into a written or spoken message. *Loci* (pronounced *low-sigh*) is the plural of *locus,* which means "place."	• To recall the four stages of Piaget's theory: For sensorimotor stage, picture a car engine with eyes, ears, nose, and a mouth. Place this image in your first location (fireplace mantel). For preoperational stage, picture Piaget dressed in a surgical gown scrubbing up before an operation. Place this image in your second location (bookshelf). For concrete-operational stage, picture Piaget as a surgeon cutting open a piece of concrete. Place this image in your third location (chair). For formal-operational stage, picture Piaget as an operating room surgeon dressed in a tuxedo. Place this image in your fourth location (sofa).	Can be used by children, college students, and the elderly to recall lists of discrete items or ideas from text passages. Works equally well for free recall and serial recall, abstract and concrete items.
Keyword	Created to aid the learning of foreign language vocabulary, but is applicable to any task in which one piece of information has to be associated with another. First, isolate some part of the foreign word that, when spoken, sounds like a meaningful English word. This is the keyword. Then create a visual image of the keyword. Finally, form a compound visual image between the keyword and the translation of the foreign word.	• Spanish word *pato* (pronounced pot-o) means "duck" in English. Keyword is *pot.* Imagine a duck with a pot over its head or a duck simmering in a pot. • English psychologist Charles Spearman proposed that intelligence was composed of two factors—*g* and *s.* Keyword is "spear." Imagine a spear being thrown at a gas (for *g* and *s*) can.	For kindergarten through fourth grade, works best when children are given keywords and pictures. Can be used to recall cities and their products, states and their capitals, medical definitions, and famous people's accomplishments.

SOURCES: Atkinson (1975); Atkinson & Raugh (1975); Bellezza (1981); Carney, Levin, & Levin (1994); Raugh & Atkinson (1975); Yates (1966).

enhanced through associations with more familiar meaningful information (for example, memory pegs or loci). Third, they provide distinctive retrieval cues that must be encoded with the material to be learned. Fourth, they force the learner to be an active participant in the learning process (Morris, 1977).

Mnemonic devices meaningfully organize information, provide retrieval cues

One example of these mnemonic benefits can be seen in a study by Russell Carney and Joel Levin (2000). They had college students use a variation of the keyword mnemonic to associate the names of twenty-four artists with a characteristic feature of each artist's style. The work of Georges Rouault, for example, is characterized by dark, heavy strokes. To help the students associate Rouault's name with his painting style, Carney and Levin supplied them with a copy of one of Rouault's paintings, a keyword (*ruler*) to help them store and recall Rouault's name, and the following direction: "Imagine making the heavy, dark lines of this painting with a *ruler* (Rouault) dipped in black paint." In comparison to a group of students who used their own methods, the mnemonic-trained students performed better on a test where they had to match the names of each artist with the paintings they had studied (82.1 percent correct versus 97.4 percent correct, respectively) as well as on a test where they had to match the names of each artist with a new painting by that artist (56.7 percent correct versus 85.1 percent correct, respectively).

A second example comes from a study done in a fourth-grade classroom with five special education students (Mastropieri, Sweda, & Scruggs, 2000). Four of these students had a learning disability with speech or language impairment, and one had a learning disability with emotional disturbance. The teacher taught all the students in the class a variation of the keyword mnemonic to help them learn social studies facts and concepts (for instance, the meaning of the concept "charter" or the name of the continent from which explorers traveled to the New World). Although the students without disabilities performed well on a unit test (88.9 percent correct for information that was taught mnemonically versus 83.3 percent for information that was not taught mnemonically), the five students with disabilities benefited even more (75 percent correct versus 36.7 percent correct).

Why You Should Teach Students How to Use Mnemonic Devices Despite the demonstrated effectiveness of mnemonic devices, many people argue against teaching them to students. They feel that students should learn the skills of critical thinking and problem solving rather than ways to recall isolated bits of verbatim information reliably. When factual information is needed, one can always turn to a reference source. Although we agree with the importance of teaching students to be critical thinkers and problem solvers, we feel this view is shortsighted for three reasons. First, it is very time-consuming to be constantly looking things up in reference books. Second, it ignores the fact that effective problem solving depends on ready access to a well-organized and meaningful knowledge base. Indeed, people who are judged to be expert in a particular field have an impressive array of factual material at their fingertips. Third, it focuses only on the "little idea" that mnemonic usage aids verbatim recall of bits of information. The "big idea" is that students come to realize that the ability to learn and remember large amounts of information is an acquired capability. Too often students (and adults) assume that an effective memory is innate and requires high intelligence. Once they realize that learning is a skill, students may be more inclined to learn how to use other tactics and how to formulate broad-based strategies.

Self- and Peer Questioning Because students are expected to demonstrate much of what they know by answering written test questions, self-questioning can be a

valuable learning tactic. The key to using questions profitably is to recognize that different types of questions make different cognitive demands. Some questions require little more than verbatim recall or recognition of simple facts and details. If an exam is to stress factual recall, then it may be helpful for a student to generate such questions while studying. Other questions, however, assess comprehension, application, or synthesis of main ideas or other high-level information.

To ensure that students fully understood how to write comprehension-aiding questions, Alison King (1992b) created a set of question stems (see Table 8.2) that were intended to help students identify main ideas and think about how those ideas related to each other and to what the student already knew. When high school and college students used these question stems, they scored significantly better on tests of recall and comprehension of lecture material than did students who simply reviewed the same material. King (1994, 1998) also demonstrated that pairs of fourth- and fifth-grade students who were taught how to ask each other high-level questions and respond with elaborated explanations outperformed untrained students on tests that measured both comprehension and the ability to integrate text information with prior knowledge.

Self-questioning improves comprehension, knowledge integration

Self-questioning is a highly recommended learning tactic because it has a two-pronged beneficial effect:

- It helps students to understand better what they read. In order to answer the kinds of question stems King suggested, students have to engage in such higher-level thinking processes as translating ideas into their own words (What is the

Table 8.2 Self-Questioning Stems

What is a new example of . . . ?
How would you use . . . to . . . ?
What would happen if . . . ?
What are the strengths and weaknesses of . . . ?
What do we already know about . . . ?
How does . . . tie in with what we learned before?
Explain why . . .
Explain how . . .
How does . . . affect . . . ?
What is the meaning of . . . ?
Why is . . . important?
What is the difference between . . . and . . . ?
How are . . . and . . . similar?
What is the best . . . , and why?
What are some possible solutions to the problem of . . . ?
Compare . . . and . . . with regard to . . .
How does . . . cause . . . ?
What do you think causes . . . ?

SOURCE: From King, A. (1992b). "Facilitating Elaborative Learning Through Guided Student Generated Questioning," *Educational Psychologist, 27* (1), 111–126. Reprinted by permission of Lawrence Erlbaum Associates, Inc.

meaning of . . . ? Explain why . . .), looking for similarities and differences (What is the difference between . . . and . . . ? How are . . . and . . . similar?), thinking about how ideas relate to one another (Compare . . . and . . . with regard to . . .) and to previously learned information (How does . . . tie in with what we learned before?), and evaluating the quality of ideas (What are the strengths and weaknesses of . . . ?). In short, answering high-level question stems leads to deeper processing of the reading material.

- It helps students to monitor their comprehension. If too many questions cannot be answered or if the answers appear to be too superficial, this provides clear evidence that the student has not achieved an adequate understanding of the passage.

Studies that have examined the effect of responding to question stems report very strong effects. The average student who responded to question stems while reading a passage scored at the eighty-seventh percentile on a subsequent teacher-made test, while the average student who did not answer questions scored only at the fiftieth percentile. Differences of this magnitude do not appear in research studies very often and, in this case, argue strongly for providing students with question stems and teaching them how to construct their own questions and answers (Rosenshine, Meister, & Chapman, 1996). Discussion of the conditions that underlie effective self-questioning instruction can be found in articles by Bernice Wong (1985) and Zemira Mevarech and Ziva Susak (1993).

Note Taking As a learning tactic, note taking comes with good news and bad. The good news is that note taking can benefit a student in two ways. First, the process of taking notes while listening to a lecture or reading a text leads to better retention and comprehension of the noted information than just listening or reading does. For example, Andrew Katayama and Daniel Robinson (2000) found that college students who were given a set of partially completed notes for a text passage and told to fill in the blank spaces scored higher on a test of application than students who were given a complete set of notes. Second, the process of reviewing notes produces additional chances to recall and comprehend the noted material. The bad news is that we know very little about the specific conditions that make note taking an effective tactic.

Taking notes and reviewing notes aid retention and comprehension

This uncertainty as to what constitutes a good set of notes probably explains the results Alison King (1992a) obtained in a comparison of self-questioning, summarizing, and note taking. One group of students was given a set of question stems, shown how to generate good questions with them, and allowed to practice. A second group was given a set of rules for creating a good summary (identify a main idea or subtopic and related ideas, and link them together in one sentence), shown how to use them to create good summaries, and allowed to practice. A third group, however, was told simply to take notes as group members normally would in class. Both the self-questioning and summarizing groups scored significantly higher on an immediate and one-week-delayed retention test.

Conclusions Regarding Learning Tactics On the basis of this brief review, we would like to draw two conclusions. One is that students need to be systematically taught how to use learning tactics to make connections among ideas contained in text and lecture, as well as between new and previously learned information. No one expects students to teach themselves to read, write, and compute. So why should they be expected to teach themselves how to use a variety of learning tactics?

The second conclusion is that learning tactics should not be taught as isolated techniques, particularly to high school students. If tactics are taught that way, most

students probably will not keep using them for very long or recognize that as the situation changes, so should the tactic. Therefore, as we implied earlier, students should be taught how to use tactics as part of a broader learning strategy.

Using Learning Strategies Effectively

Learning strategy components: metacognition, analysis, planning, implementation, monitoring, modification

The Components of a Learning Strategy As noted, a learning strategy is a plan for accomplishing a learning goal. It consists of six components: metacognition, analysis, planning, implementation of the plan, monitoring of progress, and modification. To give you a better idea of how to formulate a learning strategy of your own, here is a detailed description of each of these components (Snowman, 1986, 1987):

1. *Metacognition.* In the absence of some minimal awareness of how we think and how our thought processes affect our academic performance, a strategic approach to learning is simply not possible. At the very least, we need to know that effective learning requires an analysis of the learning situation, formulation of a learning plan, skillful implementation of appropriate tactics, periodic monitoring of our progress, and modification of things that go wrong. In addition, we need to know why each of these steps is necessary, when each step should be carried out, and how well prepared we are to perform each step. Without this knowledge, students who are taught one or more of the learning tactics mentioned earlier do not keep up their use for very long, nor do they apply the tactics to relevant tasks.
2. *Analysis.* To analyze the task and obtain relevant information, the strategic learner can play the role of an investigative journalist, asking questions that pertain to what, when, where, why, who, and how. In this way, the learner can identify important aspects of the material to be learned (what, when, where), understand the nature of the test that will be given (why), recognize relevant personal learner characteristics (who), and identify potentially useful learning activities or tactics (how).

To discover how actual teachers have aided students' information processing, see the Site-Based Cases section on the textbook web site at **http://education.college.hmco.com/students**.

Students can formulate strategic learning plans that identify and analyze the important aspects of a task. Then they can tailor these plans to their own strengths and weaknesses as learners.

APPENDIX 2.3 **Consultation Interview Narrative (Intervention 3)**

Interview Questions:

After reminding the participant that the interview will be voice recorded, and saying the interview identification number, the interviewer will read the following narrative to student:

Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."

Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I also started taking education courses because I had always been interested in the history of education. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer will ask the following questions:

1. **Have you ever thought about your own thinking or mental processes? Why or why not?**

For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes."

2. **What are your personal thoughts about your own metacognition based on this definition?**

3. **Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?**

4. **Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.**

5. **Do you have any questions for me or would you like to know anything else about Metacognition at this point?**

APPENDIX 2.4 **Metacognition Interview Description and Interview Informed Consent**

INFORMED CONSENT – INTERVIEW

The interview that you are being asked to participate in is a part of a senior research project conducted by Rachel Hanebutt. This project is being conducted as a part of Professor Eva Weisz's Education Senior Seminar course in the Education Department at DePauw University and has been designed through consultation with Professor Jamie Stockton. This is the interview intervention portion of the study. If you chose to participate in this interview you will be asked questions regarding your perceptions of your own thinking, your study habits and behaviors, and your demographic information. This interview should take approximately 15 minutes to complete.

When considering your participation in this interview, we ask that you consider the following:

- Participation is completely voluntary and you may stop participating in this at any time without penalty.
- No risks are involved and there will be no monetary benefits from participation.
- The information in this study will be kept strictly confidential (no names recorded or used). Professors will not have access to participants' surveys, answers, or identities.
- For interview purposes, an ID number will be used, however, your name and identity will not be tied to your interview.
- Your interview will be voice recorded.
- The study has been approved by DePauw's Institutional Review Board to insure that the study conforms to ethical principles in the conduct of research with human subjects.
- At the conclusion of the experimental session, the experimenters will provide their phone numbers and email addresses and the phone number and email address of the faculty sponsor. This is to enable you to contact someone should questions or complaints arise.
- After **May 10, 2015** you may contact one of the following to receive a full description of the nature, purpose and results of this study.

Rachel Hanebutt	Dr. Jamie Stockton	Dr. Eva Weisz
rachelhanebutt-2015@depauw.edu	jstockton@depauw.edu	eweisz@depauw.edu
812.630.5108	765.658.4522	765.658.1043

As a volunteer for this interview, I, _____ , the undersigned, verify that I am 18 years or over and have read and understood the conditions and rights listed above.
SIGNATURE: _____ DATE:_____

Please write the course name/number and the professor's name below.

COURSE: _____ PROFESSOR'S NAME: _____

APPENDIX 2.5 **Transcribed Metacognition Interview Interventions**

Interviewer: This is student 100 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
100: Just in a general sense? Umm, yes it is something I've considered from time to time but not in depth and maybe not in the context of studying and learning.
Interviewer: So more so just in you think of it as a fact of life?
100: Yes, more so pondering.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
100: In a broad sense? It makes sense. You can direct your avenue of thinking, you can sort of thing about what you want to think about and come to conclusions following a certain train of thought from your own mind. You can direct what you're doing, I guess.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
100: Is a simple shifting of thought or forcing yourself to be productive or to refocus, is that metacognition? Because that's done honestly every so many hours. You have to shift gears or recommit yourself to blocking people out.
Interviewer: And you see that as an internal process or a habit that you've formed?
100: I think it's internal because you have to think, and tell yourself to refocus.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
100: Yes, I took, last semester I took, organic chemistry and calculus, those were my two science and math and I took AP Calc in high school and it was really just problem based where you do the homework and practice skills and develop. And I took Calculus again just to make sure I had the foundation and it was very conceptual. It was taught differently and it was approached differently. I still ended up doing well in both but it was nice to have had the foundation of the skills and not have to worry about having the skills while conceptualizing. So I think it's important to learn the skills on your own and learn the concepts in class. I know some of my peers hadn't had calculus and struggled with it because of the balancing of the skills and the concepts. And organic chem was sort of the same way even though I had the background with chemistry but having to think through things; stuff wasn't always just a clear-cut answer. You have to think through a reaction or think through a lab and often times it helped to articulate that to someone else and have them articulate it to you and together get a valid answer. Maybe it might be a college thing but having that duality of

skills and concepts as opposed to just strictly one or the other or one at a time, having them both, can be difficult at times, it's definitely a different way of learning and being taught than what I'd previously experienced.
Interviewer: And you thought you did better at juggling those because you already had those skills?
100: In calculus especially, I didn't have to juggle those skills. It helped not having to strain about learning a skill but rather concentrate on learning the concepts.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
100: Um so are we throughout this study being taught metacognition skills?
Interviewer: (Details of the study) You were chosen for the interview section. Students get a different experience throughout the survey.
100: Are you an education major now?
Interviewer: Yes. Education and Political Science.

Interviewer: This is student 101 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
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Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
101: Ya definitely. Coming into college I definitely knew I wanted to be a science major. I've switched it around a couple of times. Coming in, I knew how to study for these majors, class, and it worked just like it did in high school. What I struggled with personally was my English, psychology and especially my philosophy class coming in. These were areas I hadn't been exposed to before; it was a big learning curve for me. This was the first time I became aware of how I think of things and how I study for things.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
101: So I think personally being aware of how you best learn and how you best study is really key to success. And so for me, when I think about how I need to learn things and how I need to study for classes, I personally have to sit down and think okay this is how I need to understand this subject and about how to understand the subject as a bigger picture. So I personally think about how I need to process things for different areas of focus. So if I'm doing a math question, I will go through the problem step by step and then I'm going to check my answer and make sure I know how to do it, not just that I got the correct answer. So for English Literature or something like that, it has always come naturally to me, but I definitely will look things up on the internet of different authors and different opinions just to make sure I'm encompassing the whole picture. Because I'm science-based, I don't always like think about different perspectives for other courses such as literature and everything else.

Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
101: Umm, I'm sure I've used it, I've just never thought about if I've used it. I think subconsciously, I've just always done what I need to do understand something so I've never sat down and thought about it deliberately. So I guess I will think about it now, well it's my last semester so it won't matter too much but for these last months I will use it to think about my learning styles.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
101: Ya I definitely do. I think DePauw is very fast-paced, especially coming in as a first year student. There's tons of different backgrounds of people coming from public and private highschools that all have their own pace. Professors are willing to help you of course, but I think that each course requires a different amount of focus or concentration. Yes it is very different from high school and from different areas or subjects. Practice makes perfect so you aren't going to know right away. After the first test, some people go in without studying at all or studying a bunch just to see what they need to do for the next step.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
101: I guess I'm just wondering what you guys are trying to look at with this study.
Interviewer: (Details of study)
101: That's awesome.
Interviewer: Thank you!

Interviewer: This is student 102 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
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Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
102: Yes, I have. Um, I guess kind of in relation to the narrative, I struggled in math classes just because I don't think I know how to study or teach myself new ways of doing math and new math processes and equations. In science classes I do know how to teach myself new material and I feel confident in that. I took a Calculus class that wasn't going well at all so I withdrew. I want to come back to it but I want to fix that problem; whether I just don't know how to take it or if I need to work on my math background.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
102: I feel like in certain subjects I am able to do that but in ones that are more challenge, like math for me, I struggle sometimes. I might get discouraged and I cannot focus anymore. I think that is the biggest problem that

I have, just not being able to understand something repeatedly and it is hard for me to focus and I don't get anywhere with that.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
102: In terms of controlling how I think about a subject? Ya, I think I have. I didn't know that was a term before this at all. But I think when I'm studying I tend to do that, to zone out other things going on around me. I guess I'll definitely use it in the future. It sounds like a great way to help you learn things.
Interviewer: Do you have any examples of experiences where you used metacognitino?
I'm having trouble of thinking of anything in particular. I know in terms of study habits, especially history and science classes, I'll read the textbook and take notes at the same time, highlighting notes inside the text. Then I'll write down what is highlighted in my own words; whatever I feel is important to do. I did that my senior year in high school. Except in calculus.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
102: Definitely with, Calculus I know it wasn't super conceptual, but from my perspective it just seemed like a lot of application. You actually had to learn how to do it. I am a geo major and it was almost entirely conceptual; actually applying concepts. It almost felt as though the tests were trivial; you can memorize facts but not really understand them. In that class [organic] I feel like you have to understand the concepts and apply them; not just memorize facts. That's the biggest difference I've seen in science and math classes here.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
102: No right now, no.
Interviewer: Awesome.

Interviewer: This is student 103 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
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Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
103: Um I don't think I've ever had to think about it because I've never been asked the question about thinking about this type of thing. I think I should; that would be good.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
103: So what do I think about my metacognition?
Interviewer: (Thinking about thinking definition)

103: I don't know that I've ever done that; had to think about it before. I didn't know that would need to be addressed because I thought everyone thought the same way. As you grow older you don't realize that everyone thinks about things differently. I don't know how I think.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
103: I don't believe I have, so I think I might be able to use it to study or in class to stay focused to think about what is being taught. I also think I could use it everyday; just for normal things.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
103: Well I've always thought that people were math and science people, or English/humanities type of people. I always thought I was a humanities person but I liked learning about science than humanities so that's the course I took. I still do better in humanities than I do in sciences even though that's my major…I think they do [require different way of thinking] but I don't have that ability. But if I could train myself to think in the way science and people should be thinking, I would have more success.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
103: I had a question earlier but I can't remember what it was.
Interviewer: (Debriefing reminder)
103: So you're just doing this for your major.
Interviewer: Yes.

Interviewer: This is student 104 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
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Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
104: Um I haven't when it came to studying because I came from an area where the academics weren't really a big deal so I didn't have to study and got straight A's and didn't have to try. So now I come to DePauw and obviously it's [academics] more/better thing to be than just athletics. So I had to think about my study habits and methods and see what works best for me.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
104: I think that I don't really think about the way I think very often; I just go with it and try to support the way I'm thinking with real ideas and stuff like that.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?

104: I used it a couple times in high school with one of my teachers that made us do it; I found it challenging to take a part in it and also like I mentioned earlier, I had to think about the way I study, but I have never thought about the way I thought.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
104: I think they do because all of the science and math classes professors preach to do more practice problems than other courses. I took a religions course last semester and the professor really stressed rereading things and memorizing certain topics and using them in different circumstances and things like that.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
104: I don't think so.
Interviewer: That's fine. Thank you.

Interviewer: This is student 105 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
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Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
105: Um not necessarily because I've never had any issues with any subjects so I've never had to stop and think "how am I thinking, do I need to change it for certain topics."
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
105: I feel as thought in regards to metacognition, I tend to alter the way I think depending on the course and professor and the way they teach it. So if it's more lecture based I tend to take more notes and follow that line. If it's more discussion based I tend to read the book more. So I change my study habits.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
105: I guess it goes back to the previous question so I guess it just depends on the professor. I'll say when I came to college and I had a professor named Leslie James, he was really big on a lot of speaking and actually answering the questions he had. I had to dig into the book and get a sense of where he was going before he went there. So that answers the question.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
105: I would say yes, just for the fact that they are a little bit harder than I expected them to be personally. I didn't necessarily have to do something different; I just had to make sure what I was doing – I had to pay more

attention than in high school. In high school you had to know one thing to know it but in college you had to know these concepts and be able to work it out.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
105: Um I was just wondering what your hypothesis is.
Interviewer: (Details of the study)
105: Okay.
Interviewer: Thank you.

Interviewer: This is student 106 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
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Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
106: I don't think that I've ever really thought about it, just because it didn't occur to me to think about it. But after we took the survey, I guess I thought about it a little, but I don't really think about it all the time.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
106: I guess for science, it's not, I feel I'm pretty good at science. I used to try to memorize everything but you can't put things together when you memorize. So when I started to understand the big picture when I thought about it I was able to understand more about it. I think in high school, senior year, I took a class, AP Biology, and my teacher asked, Why are you trying to memorize everything? So right then I realized that I could just learn the way things worked. When I took a biology class last semester I saw the same thing.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
106: I also took organic chemistry last semester and I think there are a lot of rules you can apply and they might not be stated rules to apply but everything ties in together. So if you just look at the big picture it makes sense. You don't have to memorize.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
106: I took two science classes, my seminar was a science class and then I took Spanish. So Spanish was kind of the same way because I was just trying to memorize it. I guess this time it just started to make sense. This semester I am in a mythology course and a psychology course and it's so different you have to read more…and I don't really know how to explain it.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?

106: I was just wondering why you chose this.
Interviewer: (Researcher background and explanation of narrative) Thank you.

Interviewer: This is student 108 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
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Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
108: yes because especially as you get into harder classes and need to be more time efficient, study wise. Making sure that I study as efficiently as possible is really really key, especially because I'm in three science classes this semester; it gets hard. I know I'm a really visual learner. I think that's the only way I've thought about the way my brain processes.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
108: I don't really think about my own metacognition other than when I'm tested over it. I kind of get an awareness of what my metacognition is just on how I know the information I've learned and how easily I can talk about it and how easily I can use it in everyday life.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
100: There are a couple of classes, ironically non-science classes that force you to think about what you know and what you understand. So I would have to say no. But I kind of more think about my metacognition when I encounter situations when I don't know something because it forces me to think about what I do know. Especially when teachers ask you in depth questions of like, stuff like that.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
108: No for math; Depends on the science. No for any intro to bio classes. I've taken math, and bio and then chem. Chem definitely requires a reroute for how to think about things. Just in chemistry in general, organic was the first one I took. For some people it just clicks automatically and I learned in my sophomore year in high school when I took physics that there are things that do not click in my brain. In that class, I had to pay attention to every detail and go into all the office hours. And that took a lot of work. I can memorize things pretty well, so in that class, that's not useful at all; it's complete application to different situations. It was retraining my brain how to think rather than just memorize situations. And learn how to apply it when asked.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
108: What are you planning to do with your results? What are you looking for?
Interviewer: (Details of study)

108: Oh okay.
Interviewer: Thank you.

Interviewer: This is student 109 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
109: Yes. Because I have what is called dysgraphia; I can't answer open-ended questions as well as other people can. So when I was a kid, getting asked about my opinion, when there wasn't a set answer, I had trouble saying it because it wasn't right. So I just had to learn how to study and think my answer was right, or technically the right answer.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
109: I guess for mine, I have to hear it, write it, and then say it again, in order to learn it. I think I can fairly decently control the way my mental processes work.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
109: I guess without knowing what it was I probably used it. I used to just take notes in class and then not retain the knowledge and then I noticed that I had to take the notes and then read them back to myself to learn them better.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
109: I think some of the math classes do; for mine I had to explain my processes, which I never had to do but it helped me to understand what I was doing. That was different from any other math class I've taken. My science classes are similar, my chem class is different from my bio classes. Chem is more reading and then lecture based, then writing and powerpoint. I like it better because I like seeing it all at once, instead of waiting for them to write it down.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
109: No.
Interviewer: Okay awesome.

Interviewer: This is student 110 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science.

At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
110: Ya I have because when I first got to depauw I wasn't sure what I wanted to take. I had taken a lot of science classes and a lot of art classes and when I started at DePauw I wondered which route would be the right one to take, which one would I struggle with, which one would I adapt to more, and I figured that since I'd taken more science courses than arts courses that my brain might be a little more used to dealing with the sciences than the arts. That's why I'm a science major.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
110: I think my own metacognition has been fairly strong; I don't think it's led me astray. It's not the clearest process but it's been good in telling me what I'm good at. There's been classes like political science that I'm interested but I really struggled and need to sit down and figure it out. So I think it's strong but is sometimes hard to deal with the consequences of. I discerned that I was strong at metacognition because when I started at DePauw my academics were really strong and it's continued to get stronger. Especially after taking science classes, I know that's weird to say, but biology, chemistry, physics and psychology are the four areas that I can really apply myself and have been the areas where I'm the strongest. I've used grades as a result of this strength.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
110: Last semester, microbiology (bio 250), I was kind of struggling, I was going about it the way I would with a non-science course, occasionally reading for class, talking with the professor and taking light notes during class, as a result, my grade suffered because I was trying this new study technique. But then I went back to my old study technique which was diligence and asking the professor questions, taking notes everyday, revising my notes whenever an exam should come up, and I realized that maybe in that strict, hard schedule is maybe when my best work gets done.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
110: Hmm. I'd argue not for the introductory ones. I've taken a lot of introductory math and sciences courses here. I'd argue that they don't, the professors do a great job of accommodating for a large variety of learning styles in their lesson plans, but that they gradually mold you for being ready for future science courses, actually.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
110: Have you ever experienced metacognition in your student experience at DePauw?
Interviewer: Yes, actually the student narrative is parts of my experience. I didn't actually participate or practice metacognition until I learned about it in an education class. Which is different, but has actually influenced this study with the different interventions students will go through. Yes, I have. And since then, I

will keep reflection journals and look back at my ideological and political views and see how I am structuring the things I learn and how I am learning them.
110: That's really good.
Interviewer: Any other questions? No. Okay.

Interviewer: This is student 111 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
111: Um, I mean kind of just because it's useful. We've been forced to kind of, we've always taken those tests about how do you learn and I've kind of thought about it, I feel like I can kind of learn in multiple ways, so I feel like all of them apply to me [ways of thinking].
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
111: I've never really thought about it, but I tend to pick things up pretty quickly because I've had a firm basis in the subject. Even like with chemistry here, I feel like because I've had a strong basis in chemistry, in high school, it wasn't hard to pick up on new things. Like, I feel like if you have your own way of learning and if like you have a good basis, it makes more complex ideas easier. If you understand the material, what the professor is saying, then you have your own way of thinking.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
111: Well in high school I used to write Metacognition letters. I always thought they were really sill, I didn't think they really helped. Like, we talked about "what did you learn in class or how could you have done better." I never thought it was useful to think about or think about what you're learning. There are so many different aspects to it, it's hard to put into words how you learn things, but I don't know…I mean if I really thought about [metacognition] I really could but I don't have time to do that.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
111: Um, not necessarily. I think if you don't have a good basis in it from high school then yes, it can require a lot more work or a lot more class time, but me, I had a lot of AP classes in high school, and I struggled, but now it's not a big deal for me to learn stuff. My science classes haven't been that hard. Um, ya I think they do if you're not used to that type of thing.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
111: Not really.

Interviewer: Thank you for your time.

Interviewer: This is student 112 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
112: Um, I have, as like the narrative, I also encountered problems in understanding the hard sciences. For one thing I didn't talk to my professors, I kind of just struggled through it myself. But after my first semester freshman year, I reevaluated my study habits; was I thinking about it the right way or was I just…thinking like the narrative said, I should just know this. After reevaluation, I noticed that learning hard sciences is not about confidence, but rather about having the willingness to learn in a different way.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
112: Um, I think studying for different classes, my way of studying is different for every class. It also depends on what is being taught. The professor and what he or she wants. So my own process of learning and thinking is modified to fit each course. It's very hard to study the same way for science than for soc[iology], they are different perspectives. Like I've encountered this semester, math and science is either black and white, but in a sociology class, there is no right answer for anything.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
112: Um, I think that's a little hard to answer, because I haven't really considered, how do study. I have more so just gone for it, instead of really thinking about if this is the right way to study, if this is the right way to do it and if this is the right thing to be learned. Um, I think in the future if I were to think about it, I would probably do a little more research like you're doing now, to figure out how or what the best fit for me is in learning the material I need to learn.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
100: I think it's more of the material type that is different for math and science. Say you have to learn a formula, you have to know how the formula functions, then when you're in science, you have to know how the chemical reaction occurs. You would have to know specific things in order to evaluate the function or the equation, to know what is going to happen. But in English writing or sociology, or social science, you're integrating your own opinion, as well as your own thoughts into it. In the hard sciences, it's set answers already there for you.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?

112: Um, I would like to know your result.
Interviewer: Yes, those will be available on May 10th when the study is done.

Interviewer: This is student 113 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection…

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Interviewer: This is student 114 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
114: Um I think no. I just kind of go with it, I don't really think about what I'm thinking about. I just do what I do. I've never tried to think about it.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
114: I don't think I'm really aware of it; I'm more into memorizing and stuff. I don't really know what I don't understand; I just try to memorize it. So I don't know what I know I just try to memorize.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
114: I feel like I haven't used it before; I haven't really thought about how I know. So I think I could think about my classes and what I know and how it could help me figure out what I know and use that moving forward.

Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
114: Um I'd say yes because I took AP Psych in high school and Intro Psych here, and it was the same information, just presented differently. Psych here was a lot harder than it was at my high school so I think it was challenging to think that I'd taken it before but that this was harder, the differences between the two. It was harder because the amount of work they made you do, you had to do a lot of memorizing and you couldn't really guess from it, which is what my high school was for all the classes. You had to put in a lot more work to know what it was.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
114: Um, what got you interested in this.
Interviewer: (Explanation of study and narrative)
114: That's interesting.
Interviewer: Thank you.

Interviewer: This is student 115 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
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Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
115: Um, strictly in regards to study? The only time I thought about what I'm thinking about is when I get on tangents. I can be reading a math assignment or doing physics and I will start thinking about things that have nothing to do with what I'm reading or I'll like think about an example or a question and think about it in my head, which also sends me on tangents. I think about a motion problem and think "who would actually do that?" Then I'll spend 5 minutes thinking about who would do that. Academically, I've never really thought about my thought process.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
115: Um, I think the way I at least view my own metacognition is that it is useless and that I am not good at it. When I try to think about it too much I go on random tangents, it gets me away from what I'm really trying to do. It's useless academically. They're fun just to think about but kind of trying to think about a GPA, side thoughts going on in my head are useless.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
115: I definitely use metacognition to, because I'm a physics major and doing biochemistry and chemistry too, so I think metacognition would help in thinking about the relation between the things I do. I've seen how they

overlap, but it takes me a while to do that. I think if I was better at metacognition, I could interrelate those on the spot.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
115: Um, as opposed to high school? All of my intro courses that I took were at least in most parts similar to what I've done before except for mythology and religion, which had more to do with people rather than strict numbers, what I do more of, so I don't know how to answer that. I think the intro courses I've taken outside of the sciences think more about people and social interactions, in comparison to science and math that think about numbers and concepts.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
115: Um, what do you consider/how do you consider someone "good" at metacognition?
Interviewer: This is going to be my personal definition, everyone has their own level and own type of metacognition, obviously we are not all good at the same things or thinking in the same ways, but truly getting in control of your own metacognition or thinking about the way you think (it's funny to say, right), is an individualized process and there is really no way to judge if someone is good or bad at it. You talked about the "useless" so I think someone could gauge their own metacognitive skill on that, but that doesn't necessarily mean they aren't metacognitively cognoscente…
115: Awesome.
Interviewer: Thank you.

Interviewer: This is student 116 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
116: Yes. Because as a psychology major, I think it really important to think more outside of just the basic guidelines of the classroom; I'm starting to think more about how I can learn better, what kind of material am I getting, just in general.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
116: I think I overestimate myself. I personally think that I can do more than what I can handle, I know I can do this task, and three other tasks. But I often try to do more than what I can actually accomplish. So, sometimes my metacognition is sometimes very flawed. (Are you talking about your physical performance?) Yes, reading, just getting through school work in general.

Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
116: Yes, so in high school, I had direct experience with it. Our English teacher actually had us write metacognition journals, we had to write a reflection after we finished writing a paper. We had to go back and write about what we were thinking about when we were writing the paper. And when I got here to DePauw, I had to do the exercises for my psych class and my education classes too, I had to think about what my thought process was when I was doing an assignment or when I was thinking about a research article or different articles or reading we had to do.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
116: Yes, it's very objective. I'm taking Chem 130 right now and it is very hard for me to understand that there is a formulaic way of learning things. Because I'm a discusser, I like to be able to talk about things and more complex ideas, whereas Chemistry 130, you have to know the nomenclature and how to name it. There is only one answer, maybe two and you just have to name it and move on. So I have a very hard time with that.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
116: Ya, how can metacognition directly affect or how can professors start implementing it more in the classroom?
Interviewer: So this is my personal opinion, this study is trying to figure that out (explain research methods, explain study, etc…)
116: Okay
Interviewer: Thank you.

Interviewer: This is student 117 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
117: Um, I'm not really sure how to answer that. I haven't really thought about it as analytically when that student switched majors and when he or she realized that they were thinking about things in the wrong way.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
117: Um, I guess the part of the definition, being able to manipulate, like my cognition, I hadn't really dove into changing something, but um…I guess being open to other ways of thinking would definitely help in different subjects, like science versus arts and humanities because they are totally different ways of thinking.

Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
117: Um, like in terms of studying? I know that I've seen like a Ted talk about people who go to conventions an memorize strings of numbers and attach a string of three or four numbers to something in their house. I haven't personally tried that kind of memorization, but using acronyms and that kind of thing, nothing like that.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
117: Compared to the arts and humanities classes, yes. I guess my first reaction is a different pace, but I guess in humanities it's kind of not a black and white answer, so if you can present something and argue with substantial evidence, then you're okay, it's good, but in math and science, you're either right or you're wrong. There's not a lot of wiggle room.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
117: Can I ask where you're going with with this study?
Interviewer: (Explain study and questions asking)
100: That's cool.
Interviewer: Thank you.

Interviewer: This is student 118 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
118: I have, but I think that's mostly because I'm an anthropology minor and a geo major. I realized the way of thinking for each field is different, in anthropology you have to think of it in the humanistic way and in geology and other hard sciences you have to think of it in the objective way.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
118: I mean, I don't know I guess it's different for me because I've been involved with science my whole life, science has been my favorite subject. I just understood math and science. The same goes for social sciences too, I just understood it. When it comes to metacognition, that's a hard question. I don't know what to say about that, I do think about what I think sometimes but it's not over my head sometimes.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
118: You know how they say when you're brought up in different languages you think in different language. Spanish was my first language and I learned English when I was four, so sometimes I try to think in Spanish,

even though I don't speak that much Spanish anymore. In Spanish you can describe things in a prettier way, depending, and Spanish is a mix of angry and happiness, and my own thinking is passionate. And English is okay, it's just, the word to describe English would be, not boring, but not as passionate.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
118: Yes. I mean, I know, you kinda have to think about in introductory classes, they try to stuff as much as they can in an intro class, it's understandable, but all the little pieces you have to piece together and make a whole out of them. When I took earth and the environment and when I was taking sociology last semester, I felt that way too. She would teach different parts an try to piece it all together at the end and how it relates to our society. I kind of see how these fields are the same when you have to piece them together, but when you're studying for them differently, I guess, it's a hard question.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
118: Yes, why metacognition exactly?
Interviewer: (Explain study and background)
118: Okay.
Interviewer: Thank you.

Interviewer: This is student 119 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
119: Sometimes, not like all the time or really in depth. I think about how to study and how to learn best.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
119: I don't know. I don't have a lot of metacognition, but I have some understanding of how I think and how I learn I guess.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
119: Not in a formal way, I don't know, I have thought about how when I study for a test and do well I've used that method that helped me study for that test on the next test. I don't usually use flashcards, but I did to help remember vocab words, so I continued to do that later.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.

119: I'm not sure. The only other science class I've taken here is biology and I'd have to think more but I don't think so.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
119: What are you doing this for?
Interviewer: (Explain study).
119: Okay.
Interviewer: Thank you.

Interviewer: This is student 120 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
120: I have, but I don't know.. I'm a philosophy major and one of the areas I've paid attention to is Metcognition.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
120: Based on that definition, I am aware of the thought processes I do have, but the manipulation of them is not the easiest thing.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
120: I could use metacognition to actually study for the sciences. When it comes to sciences, I am also a philosophy major so I had chemistry stuff like everywhere so if I looked away, I would see it.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
120:I have not taken introductory math, so I have no idea on that but for any of the sciences, it's a completely different thought process that most people aren't used to. It might seem more scientific, people might see it that way and that might be a problem. In a liberal arts school you should be able to use different parts of the brain. But memorization, manipulation and application is the way one should learn the sciences, but like in other countries that's how they do it. Compared to here they do it a lot better because of the way they learn.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
120: I'm good.
Interviewer: Thank you.

Interviewer: This is student 122 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
122: In regards to school, I haven't thought about my own thinking or mental processes. Sometimes somebody says something in conversation and it comes up, but as far as class goes, I've never thought about the mental or thinking processes of learning. Outside of class I've had conversations with people, a random subject, and I'll make some off-handed comment and someone will ask, "why do you think that," and I'll have to go back and think why I thought that or why I made that decision and I have to analyze the various thought patterns that went through. That happens regularly but not often for school.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
122: I'm not really sure what to think of my metacognition and metacognitive abilities. I'm usually aware of the types of things I know and how well I know them but I can't really manipulate them; I learn things in a linear process and that's how I learn them usually/tackle most problems. As such, by that definition of metacognitive ability, I don't have a whole lot of it. In terms of studying, studying is something I could do a lot better, I have noticed as far as remembering things that I can read it and remember exactly what I read, however, I haven't paid attention to my own thought processes.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
122: I haven't. Obviously there is the studying application. I don't know, I can't think of something. I can see how it would be useful in an academic environment for studying and test taking and would be useful for knowing information in any environment. Other than that I can't really think of any way it would come in handy.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
122: Between science and other courses? I feel like there is a different thought process involved. I can't really put my finger on why it is different, but that's one of the reasons I decided to go into the sciences. There's something different about it that pulls me into it more.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
122: I don't have any.
Interviewer: Awesome.

Interviewer: This is student 123 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
123: I think we all have in some way, just because school forces us to think about how we think and kind of get us to change how we think in a way and form new perspectives in a way. So ya I have.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
123: I think I'm not really aware of how much I know because it's so hard, introspection is so hard and knowing how you study is so hard because it is so subjective and a lot of the work is objective.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
123: I don't think I've ever used it. Again, it's really hard to know how you think and to manipulate how you think in each of the courses you're taking. There are certain courses that allow you to step outside of yourself and be more free and liberal in your thinking and allow you to be more creative in your thinking and there are those that don't allow you to be as creative in your thinking. So I don't think I've ever used it.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
123: I don't think so. I think it is the same as high school. Learn this information, learn this. In comparison to other courses at DePauw, it's obviously more objective. There are courses that force you, religion courses force you to think outside the box. Leslie James, if you've ever had class with him, he is really outside the box, great professor, but really forces you to think outside of that narrow box that high school taught you.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
123: No I'm good.
Interviewer: Thank you.

Interviewer: This is student 124 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other

courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
124: Yes so I want to say that at the beginning at my career here at DePauw, studying for the sciences was something I had to go about differently. I started using different study techniques, I was more involved with flashcards or meeting up with a group of friends, or meeting up with my friends, and these extra measures made me think, okay I have to take alternatives to figure this out.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
124: Personally, I think the way my brain works, I'm a bit more hard-wired toward science, so I think probably in a way where I have to organize my thoughts in order to study. I actually find myself writing lists of things I have to do and things I have to study before in order to get more time. So when thinking about my metacognition, I'm more of an organized, type learner. I have to be able to work problems out or see them myself for me to be able to understand.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
124: Okay so, I have used metacognition before, through flashcards or through looking at my notes or writing my notes, because that refreshes my memory. I've definitely taken a different viewpoint of how to use it in high school versus how to use it in college.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
124: Um, definitely, especially if you haven't taken a chemistry course in a while or a math course in a semester, it can make you a little bit scared because you're presented with all this material and expected to understand it. I think there are enough resources at DePauw to get an understanding of how you can overcome that.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
124: I'm actually interested in how you would tie this into more people who are trying to learn more about the sciences – middle school-ers?
Interviewer: Personal experience with metacognition journals, but students don't really understand why they are doing it…accessing metacognition…
124: Okay. I see that.
Interviewer: Thank you.

Interviewer: This is student 125 and I am reminding the participant that the interview will be recorded. Here's the student narrative: Personally, I have encountered a lack of confidence in understanding the hard sciences. Taking a few hard sciences courses in high school, I gained the false confidence that I was skilled in science. At DePauw, I was initially interested in being a chemistry major, but was unaware of my own science education gap. Utilizing science professors, the Q Center, and other resources, I still struggled in my science courses. Frustration quickly set in, but my resilient nature and refusal to quit forced me to continue taking chemistry courses. I remember not being able to understand why I couldn't learn, or at least why I felt as though I couldn't learn. I studied more for my science classes than for any other, receiving grades worse than all other

courses. I asked for help (something I was not used to doing) and met weekly with professors to diagnose my problem. Some said I had a "math retardation," while others simply said I need to study differently, but it seemed that no matter what I tried, thinking and learning in science was "not my thing."
Realizing that I would either continue sacrificing my GPA or despise the rest of my academic time at DePauw, I decided to switch to a major in Political Science. I started to realize that I had been looking at my own struggles in the wrong way. It was through reflection on my own experience and acknowledgement of developmental phases and stages that I was finally able to understand my lack of metacognition and understanding of science thinking. I had been going about learning science in all the wrong ways.

Interviewer: Your first question is, Have you ever thought about your own thinking or mental processes? Why or why not?
125: Ya well um lately I've been kind of thinking on ways to do it, especially after that one paper you gave us. I thought about it, I actually do use flashcards if I need it, or I look through notes for humanities, but if we're going through science stuff, I see that, you know, I need to have something there to remember or some sort of mini test just so I know I get this right. I feel like I need it because if I don't, I may not remember it, there are some things in science that are so complex that you don't know if you will remember it in a day or a week or for the test or something and it's always good to be there just for handy and maybe later for a lab.
Interviewer: For the purpose of this study, the definition of "Metacognition" is "the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes." What are your personal thoughts about your own metacognition based on this definition?
125: Okay so it's like you're supposed to see how we work together with our mind? I kind of see it as that I can focus on my stuff when I work but I feel like I need to just find a way to sit down and focus if I want to make sure I learn the best. Studying routines, I make sure that I don't have anything to distract me and that I can just sit there and do what I need to do.
Interviewer: Have you used metacognition before? If yes, could you describe those experiences? If no, how do you think you might be able to use metacognition?
125: I'm not really sure if I have or not, because I haven't really heard of the term before this little test you're doing. So I would say that if I did know about it in the past I would have used it more to my advantage to make sure I could understand things clearer and would have been able to say this is my strength and this is my weakness for what I'm studying for. So maybe I should try doing this instead of this.
Interviewer: Do you think that introductory math and science courses at DePauw require a different way of thinking? Please explain.
125: Yes I definitely think so. I took a Chem 170 class last semester and I swear that I need to redo my study schedule from what I would have done on a regular chemistry course because there is so much more that you need to remember and it needs to be done differently than a humanities course. I was also taking Mediterranean history class and in that one all I did was write notes and look over the notes but when I was looking for something like chemistry, I had to do flashcards, I had to do kill and drill on chemistry tests. And I passed both alright, it's just a completely different way of doing things if you have to do science over humanities.
Interviewer: Do you have any questions for me or would you like to know anything else about Metacognition at this point?
125: I think I'm good.
Interviewer: Thank you.

APPENDIX 3.1 **Metacognition Survey 2**

Part IA

1. Which of the following interventions was assigned to you?

Handout/ "How-to" Article/10 pgs. Individual Interview No Intervention

2. To which degree did you utilize and take advantage of your intervention?

Fully Mostly Partially Little to None None

Part IB

Directions – Circle the answer that best reflects your personal position on the following statements.

10. The intervention circled above was helpful.

Strongly Agree Agree Neutral Disagree Strongly Disagree

11. The intervention circled above was effective.

Strongly Agree Agree Neutral Disagree Strongly Disagree

12. The intervention circled above was a waste of time.

Strongly Agree Agree Neutral Disagree Strongly Disagree

13. The intervention circled above helped me to understand metacognition.

Strongly Agree Agree Neutral Disagree Strongly Disagree

Part IC

In you own words, was your intervention effective or not effective? Why?

What would you have changed about your intervention to make it more effective?

What is your personal definition of "Metacognition?"

Part ID

Directions – Circle the answer that best reflects how your personal position on the following statement has ***changed since the first survey.***

1. I study differently for different types of courses (i.e. Science/Math, Humanities, etc.).

   More true Less false Same Less true More false

2. I study differently for math and science courses, specifically.

   More true Less false Same Less true More false

3. I struggle with deciding how to study.

   More true Less false Same Less true More false

4. I think about how I think and learn.

   More true Less false Same Less true More false

5. I think about how my mind works.

   More true Less false Same Less true More false

6. I use metacognition.

   More true Less false Same Less true More false

Part ID Comments (Please elaborate on any of your answers in this section):

Part IE

Directions – Circle the answer that best reflects how the following quote applies to you.

1. “I think therefore I am."

   Strongly Agree Agree Neutral Disagree Strongly Disagree

2. "Imagination is more important than knowledge."

   Strongly Agree Agree Neutral Disagree Strongly Disagree

3. "Students can learn to think better if schools concentrate on teaching them how to do so."

   Strongly Agree Agree Neutral Disagree Strongly Disagree

4. “Cognitive strategies are used to help achieve a particular goal while metacognitive strategies are used to ensure that the goal has been reached.”

Strongly Agree Agree Neutral Disagree Strongly Disagree

5. “To read without reflecting is like eating without digesting.”

Strongly Agree Agree Neutral Disagree Strongly Disagree

6. “To make an individual metacognitively aware is to ensure that the individual has learned how to learn."

Strongly Agree Agree Neutral Disagree Strongly Disagree

Part IE Comments (Please elaborate on any of your answers in this section):

Part IF

For the purpose of this study, the definition of “Metacognition” is **“the awareness of one’s own knowledge and one’s ability to understand, control, and manipulate one’s cognitive processes.”**

Based on this definition, circle the answer that best reflects your personal position on the following statements.

4. I understand my own thinking processes.

Strongly Agree Agree Neutral Disagree Strongly Disagree

5. I control my own thinking processes.

Strongly Agree Agree Neutral Disagree Strongly Disagree

Part ID Comments (Please elaborate on any of your answers in this section):

Part II - Demographics

Graduation Year? 2015 2016 2017 2018 Other: _____

Academics? Major(s): _____

GPA Range: 4.0-3.5 3.49-3.0 2.99-2.5 2.49-2.0 Other/Prefer not to answer

How do you identify? Female Male Prefer not to respond

How do you describe yourself?

American Indian/Native American Hispanic/Latino Other: _____

Asian White/Caucasian Prefer not to answer

Black/African American Pacific Islander

APPENDIX 3.2 **Metacognition Study Description and Informed Consent**

STUDY DESCRIPTION

The survey that you are being asked to participate in is a part of a senior research project conducted by Rachel Hanebutt. This project is being conducted as a part of Professor Eva Weisz's Education Senior Seminar course in the Education Department at DePauw University and has been designed through consultation with Professor Jamie Stockton.

This two-part in-class survey will focus on undergraduate introductory science or math student thinking and study behavior/habits and will include the variable of an intervention, which has been assigned to your class and will occur between the two surveys. You will be taking the *second* survey today. If you chose to participate in this survey you will be asked questions regarding your perceptions of your own thinking, your study habits and behaviors, and your demographic information. This survey should take approximately 5-10 minutes to complete. Reminder: Your class was assigned one of the following intervention types and you will be asked questions about your intervention type.

Intervention Name	Description
Handout	A handout, which you are encouraged to read and use to your advantage this semester.
Article	An article, which you are encouraged to read and use to your advantage this semester.
Student Interview	An out of class student interview, which will take approximately 15 minutes.
No Intervention	Control group – only takes survey

When considering your participation in this study, we ask that you consider the following:

- Participation is completely voluntary and you may stop participating in this at any time without penalty.
- No risks are involved and there will be no monetary benefits from participation.
- The information in this study will be kept strictly confidential (no names recorded or used). Professors will not have access to participants' surveys, answers, or identities.
- The study has been approved by DePauw's Institutional Review Board to insure that the study conforms to ethical principles in the conduct of research with human subjects.
- At the conclusion of the experimental session, the experimenters will provide their phone numbers and email addresses and the phone number and email address of the faculty sponsor. This is to enable you to contact someone should questions or complaints arise.
- After **May 10, 2015** you may contact one of the following to receive a full description of the nature, purpose and results of this study.

Rachel Hanebutt	Dr. Jamie Stockton	Dr. Eva Weisz
rachelhanebutt-2015@depauw.edu	jstockton@depauw.edu	eweisz@depauw.edu
812.630.5108	765.658.4522	765.658.1043

As a volunteer for this interview, I, _____ , the undersigned, verify that I am 18 years or over and have read and understood the conditions and rights listed above.

SIGNATURE: _____ DATE:_____

Please write the course name/number and the professor's name below.

COURSE: _____ PROFESSOR'S NAME: _____

APPENDIX 3.3 **Metacognition Survey 2 - Instructions for Professors**

Thank you for participating in this two-part survey with intervention. This final survey will take approximately 5-10 minutes for students to take and 15 minutes to completely administer. Your role as the instructor is to pass out the survey packets and to allow students to participate if they choose to do so. Each survey has an informed consent sheet with a description of the study. **Every student has the opportunity to fill out this survey, even if they did not take the first one.** If the students have any questions regarding the study, its intentions, or the project as a whole, please feel free to direct them to any of the three contacts on the first page of the survey.

Each student who decides to participate must fill out and sign the informed consent (the first page of the survey). Then, students may choose to fill out the survey and provide demographic information. If a student does not feel comfortable answering a question on the survey, they are not obligated to do so. After students have completed their survey, please have them place the survey packet in the envelope I have provided to you. **You may then return the envelope to me via campus mail (UB Box 5950) or email me and I can pick it up.**

Please remind the students the intervention type they participated with before administering the survey:

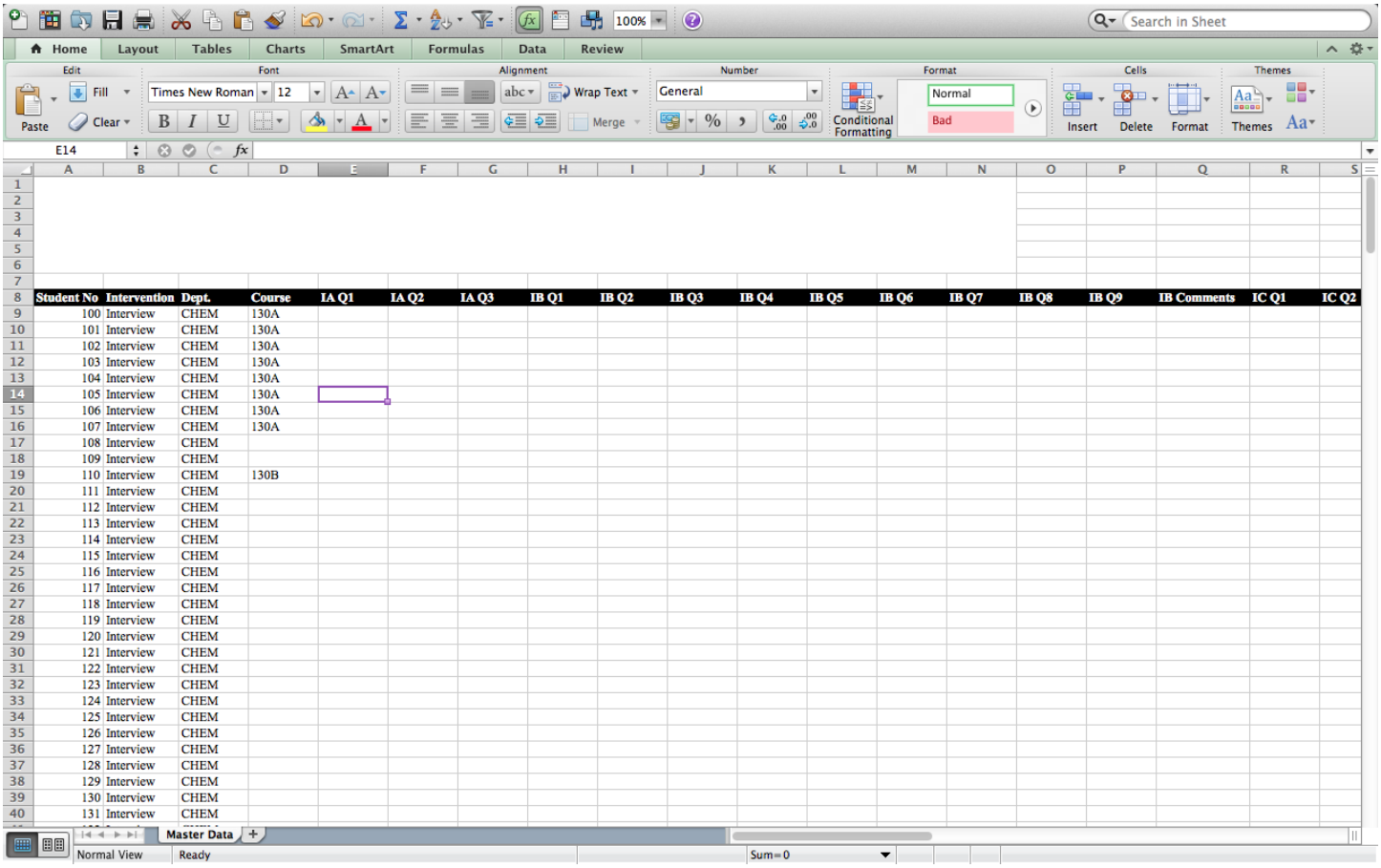
Handout – After students have turned in their survey packet, please give them a copy of the Metacognition How-To Handout and encourage them to read and take advantage of the material.

Article – After students have turned in their survey packet, please give them a copy of the Metacognition Article and encourage them to read and take advantage of the material.

Interview – After students have turned in their survey packet, please ask and encourage them to sign up for a 15-minute time slot for interview. If there is not a time slot that fits with their schedule, please encourage them to contract me via email or phone (listed on the interview sheet). If students have questions about this interview, please assure them that it will be a short informative session and that they will not need to know any particular information for participation.

No Intervention – Survey only

APPENDIX 4.1 **Data Spreadsheet Setup**



Student No	Intervention	Dept.	Course	IA Q1	IA Q2	IA Q3	IB Q1	IB Q2	IB Q3	IB Q4	IB Q5	IB Q6	IB Q7	IB Q8	IB Q9	IB Comments	IC Q1	IC Q2
100	Interview	CHEM	130A															
101	Interview	CHEM	130A															
102	Interview	CHEM	130A															
103	Interview	CHEM	130A															
104	Interview	CHEM	130A															
105	Interview	CHEM	130A															
106	Interview	CHEM	130A															
107	Interview	CHEM	130A															
108	Interview	CHEM																
109	Interview	CHEM																
110	Interview	CHEM	130B															
111	Interview	CHEM																
112	Interview	CHEM																
113	Interview	CHEM																
114	Interview	CHEM																
115	Interview	CHEM																
116	Interview	CHEM																
117	Interview	CHEM																
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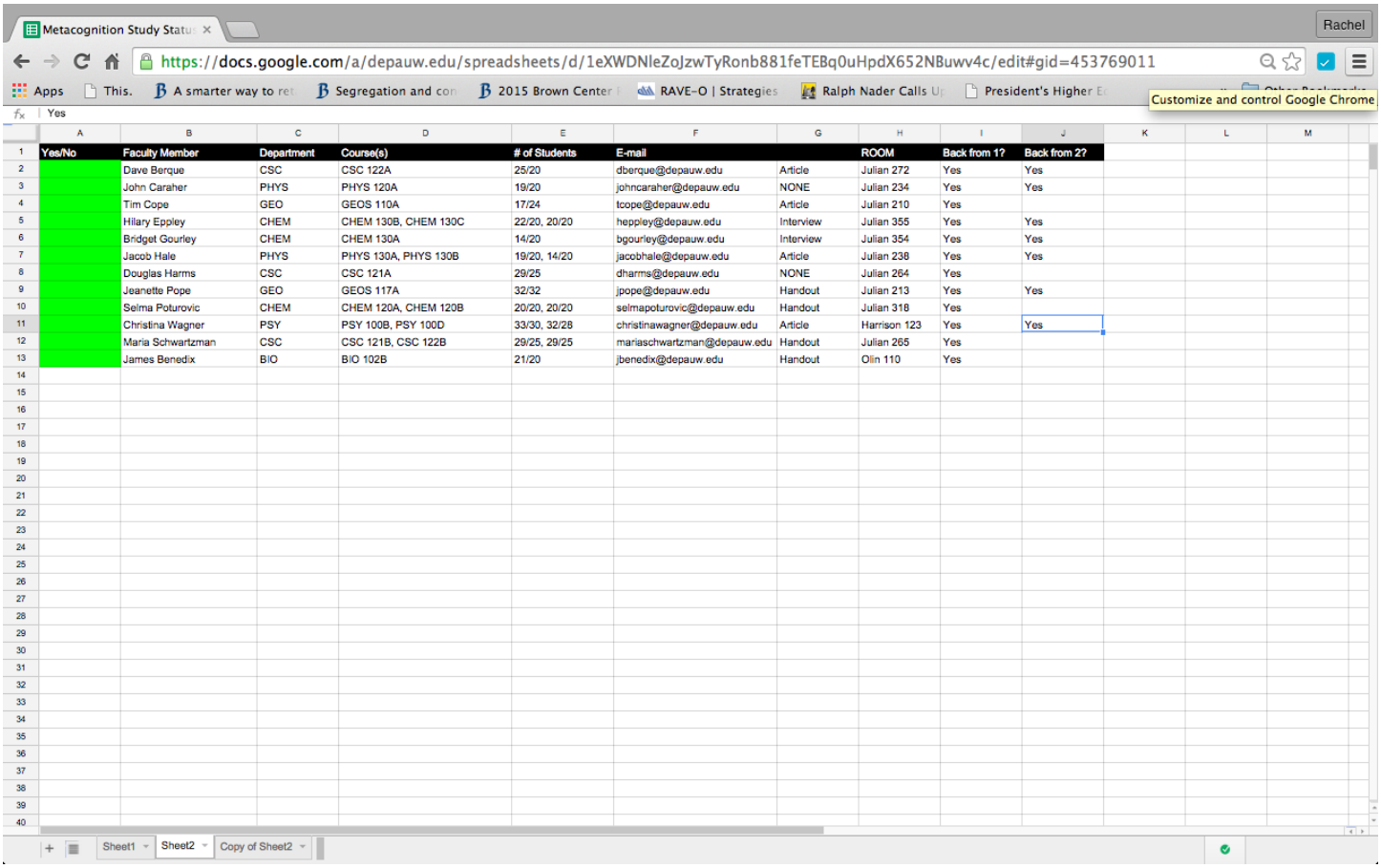
122	Interview	CHEM																
123	Interview	CHEM																
124	Interview	CHEM																
125	Interview	CHEM																
126	Interview	CHEM																
127	Interview	CHEM																
128	Interview	CHEM																
129	Interview	CHEM																
130	Interview	CHEM																
131	Interview	CHEM																

APPENDIX 4.2 **Metacognition Status Sheet**



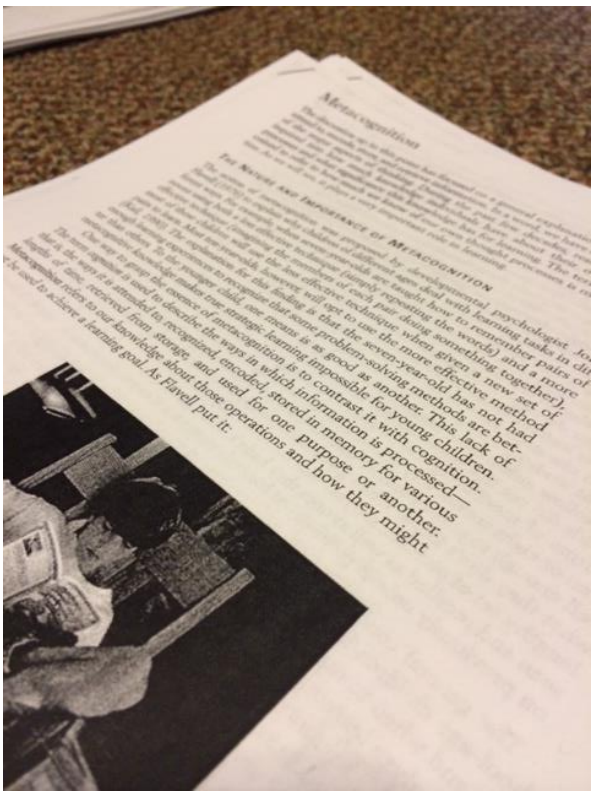
Yes/No	Faculty Member	Department	Course(s)	# of Students	E-mail		ROOM	Back from 1?	Back from 2?
	Dave Berque	CSC	CSC 122A	25/20	dberque@depauw.edu	Article	Julian 272	Yes	Yes
	John Caraher	PHYS	PHYS 120A	19/20	johncaraher@depauw.edu	NONE	Julian 234	Yes	Yes
	Tim Cope	GEO	GEOS 110A	17/24	tcope@depauw.edu	Article	Julian 210	Yes	
	Hilary Eppley	CHEM	CHEM 130B, CHEM 130C	22/20, 20/20	heppley@depauw.edu	Interview	Julian 355	Yes	Yes
	Bridget Gourley	CHEM	CHEM 130A	14/20	bgourley@depauw.edu	Interview	Julian 354	Yes	Yes
	Jacob Hale	PHYS	PHYS 130A, PHYS 130B	19/20, 14/20	jacobhale@depauw.edu	Article	Julian 238	Yes	Yes
	Douglas Harms	CSC	CSC 121A	29/25	dharms@depauw.edu	NONE	Julian 264	Yes	
	Jeanette Pope	GEO	GEOS 117A	32/32	jpope@depauw.edu	Handout	Julian 213	Yes	Yes
	Selma Poturovic	CHEM	CHEM 120A, CHEM 120B	20/20, 20/20	selmapoturovic@depauw.edu	Handout	Julian 318	Yes	
	Christina Wagner	PSY	PSY 100B, PSY 100D	33/30, 32/28	christinawagner@depauw.edu	Article	Harrison 123	Yes	Yes
	Maria Schwartzman	CSC	CSC 121B, CSC 122B	29/25, 29/25	mariaschwartzman@depauw.edu	Handout	Julian 265	Yes	
	James Benedix	BIO	BIO 102B	21/20	jbenedix@depauw.edu	Handout	Olin 110	Yes	

APPENDIX 4.3 **ID Number Assignments**

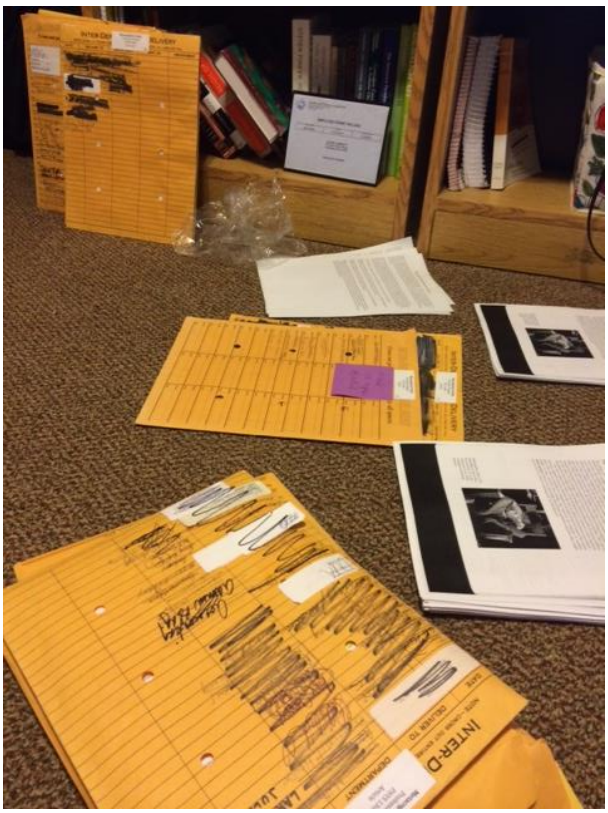
Number	Intervention Type
100-199	Interview Consultation
200-399	"How-to" Sheet
400-599	Article
600-699	No Intervention (Control Group)/Did not attend Interview
700-799	Did not take first survey

APPENDIX 5.1

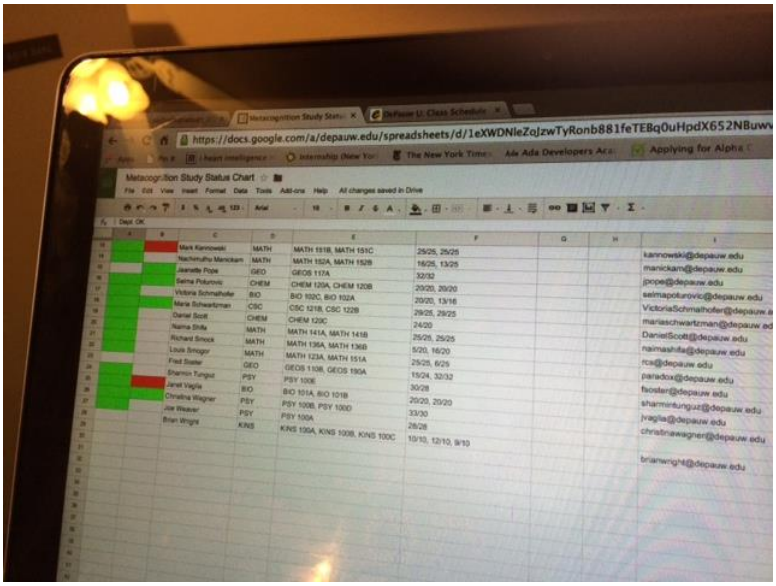
Picture Documentation



5.1a Copies of Metacognition Article (Intervention 2)



5.1b Preparing survey and intervention envelopes for each course and faculty member



5.1c Online documentation of study status and participant confirmations

5.1d A tired but happy researcher, carrying the second survey from print

APPENDIX 6.1 **Interview Data Guide (1 to 5 scale)**

Each interview question is evaluated based on the following criteria.

1 – Response is weak with little to no reflection on metacognition or any applicable experiences.

2 – Participant attempts to respond to question but does not provide solid evidence of awareness of metacognition or participant's ability to reflect on his or her experiences.

3 – Participant's response demonstrates awareness of metacognition and shows participant's ability to reflect on his or her experiences.

4 – Participant's response demonstrates awareness of metacognition and shows participant's ability to reflect on his or her experiences multiple times, connecting this act to metacognition.

5 – Response includes complete acknowledgement and awareness of all metacognitive processes and demonstrates participant's ability to adequately reflect on his or her experiences, control his or her cognitive processes and regulate his or her learning strategies.

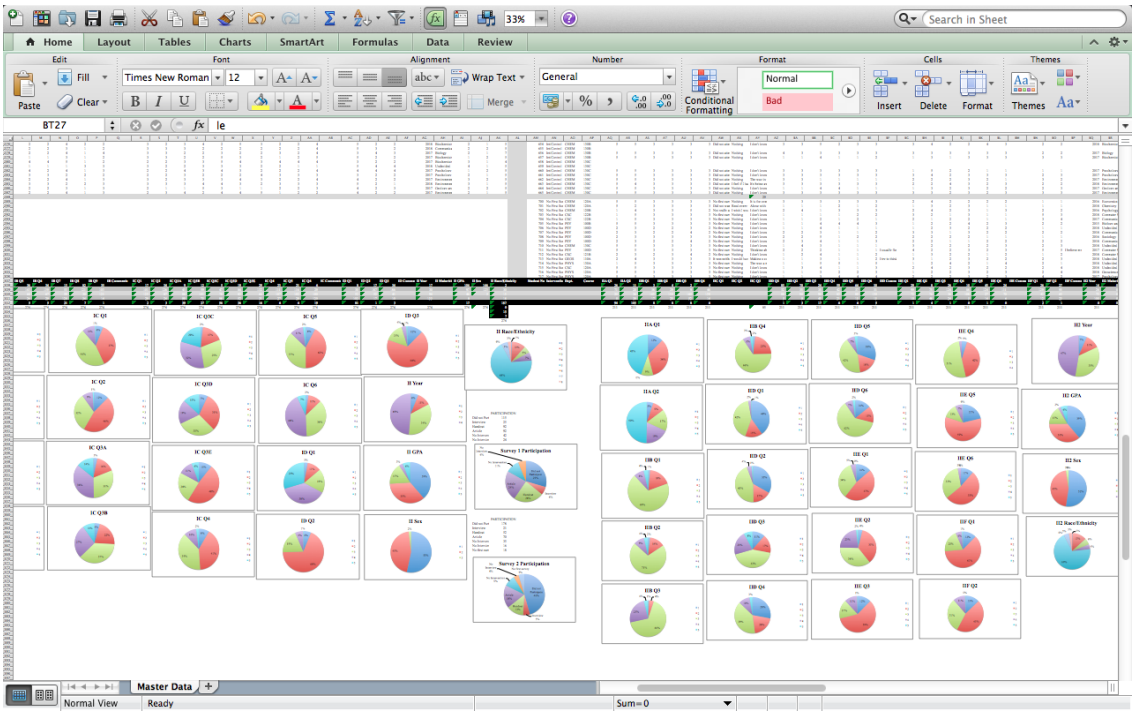
APPENDIX 6.2

Interview Number	Average Ranking	Notable Student Quote
100	4	"You can direct your avenue of thinking, you can sort of thing about what you want to think about and come to conclusions following a certain train of thought from your own mind."
101	3	"I think personally being aware of how you best learn and how you best study is really key to success. And so for me, when I think about how I need to learn things and how I need to study for classes, I personally have to sit down and think okay this is how I need to understand this subject and about how to understand the subject as a bigger picture. So I personally think about how I need to process things for different areas of focus."
102	3	"It almost felt as though the tests were trivial; you can memorize facts but not really understand them. In that class [organic] I feel like you have to understand the concepts and apply them; not just memorize facts. That's the biggest difference I've seen in science and math classes here."
103	1	"But if I could train myself to think in the way science and people should be thinking, I would have more success."
104	2	"I think that I don't really think about the way I think very often; I just go with it and try to support the way I'm thinking with real ideas and stuff like that.
105	2	"I tend to alter the way I think depending on the course and professor and the way they teach it. So if it's more lecture based I tend to take more notes and follow that line. If it's more discussion based I tend to read the book more. So I change my study habits."
106	1	"I don't think that I've ever really thought about it, just because it didn't occur to me to think about it. But after we took the survey, I guess I thought about it a little, but I don't really think about it all the time."
108	3	"I don't really think about my own metacognition other than when I'm tested over it. I kind of get an awareness of what my metacognition is just on how I know the information I've learned and how easily I can talk about it and how easily I can use it in everyday life."
109	3	"I guess for mine, I have to hear it, write it, and then say it again, in order to learn it. I think I can fairly decently control the way my mental processes work."
110	2	"I discerned that I was strong at metacognition because when I started at DePauw my academics were really strong and it's continued to get stronger. Especially after taking science classes, I know that's weird to say, but biology, chemistry, physics and psychology are the four areas that I can really apply myself and have been the areas where I'm the strongest. I've used grades as a

		result of this strength.”
111	2	“There are so many different aspects to it, it’s hard to put into words how you learn things, but I don’t know…I mean if I really thought about [metacognition] I really could but I don’t have time to do that.”
112	5	“But after my first semester freshman year, I reevaluated my study habits; was I thinking about it the right way or was I just…thinking like the narrative said, I should just know this. After reevaluation, I noticed that learning hard sciences is not about confidence, but rather about having the willingness to learn in a different way.”
114	1	“I feel like I haven’t used it before; I haven’t really thought about how I know. So I think I could think about my classes and what I know and how it could help me figure out what I know and use that moving forward.”
115	4	“The only time I thought about what I’m thinking about is when I get on tangents. I can be reading a math assignment or doing physics and I will start thinking about things that have nothing to do with what I’m reading or I’ll like think about an example or a question and think about it in my head, which also sends me on tangents.”
116	3	“Our English teacher actually had us write metacognition journals, we had to write a reflection after we finished writing a paper. We had to go back and write about what we were thinking about when we were writing the paper. And when I got here to DePauw, I had to do the exercises for my psych class and my education classes too, I had to think about what my thought process was when I was doing an assignment or when I was thinking about a research article or different articles or reading we had to do.”
117	2	“I guess being open to other ways of thinking would definitely help in different subjects, like science versus arts and humanities because they are totally different ways of thinking.
118	4	“You know how they say when you’re brought up in different languages you think in different language. Spanish was my first language and I learned English when I was four, so sometimes I try to think in Spanish, even though I don’t speak that much Spanish anymore. In Spanish you can describe things in a prettier way, depending, and Spanish is a mix of angry and happiness, and my own thinking is passionate. And English is okay, it’s just, the word to describe English would be, not boring, but not as passionate.”
119	3	“Not in a formal way, I don’t know, I have thought about how when I study for a test and do well I’ve used that method that helped me study for that test on the next test. I don’t usually use flashcards, but I did to help remember vocab words, so I continued to do that later.”

120	4	“In a liberal arts school you should be able to use different parts of the brain. But memorization, manipulation and application is the way one should learn the sciences, but like in other countries that’s how they do it. Compared to here they do it a lot better because of the way they learn.”
122	4	“I’m usually aware of the types of things I know and how well I know them but I can’t really manipulate them; I learn things in a linear process and that’s how I learn them usually/tackle most problems.”
123	3	“There are certain courses that allow you to step outside of yourself and be more free and liberal in your thinking and allow you to be more creative in your thinking and there are those that don’t allow you to be as creative in your thinking. So I don’t think I’ve ever used it.”
124	5	“I think the way my brain works, I’m a bit more hard-wired toward science, so I think probably in a way where I have to organize my thoughts in order to study. I actually find myself writing lists of things I have to do and things I have to study before in order to get more time. So when thinking about my metacognition, I’m more of an organized, type learner. I have to be able to work problems out or see them myself for me to be able to understand.”
125	4	“I kind of see it as that I can focus on my stuff when I work but I feel like I need to just find a way to sit down and focus if I want to make sure I learn the best. Studying routines, I make sure that I don’t have anything to distract me and that I can just sit there and do what I need to do.

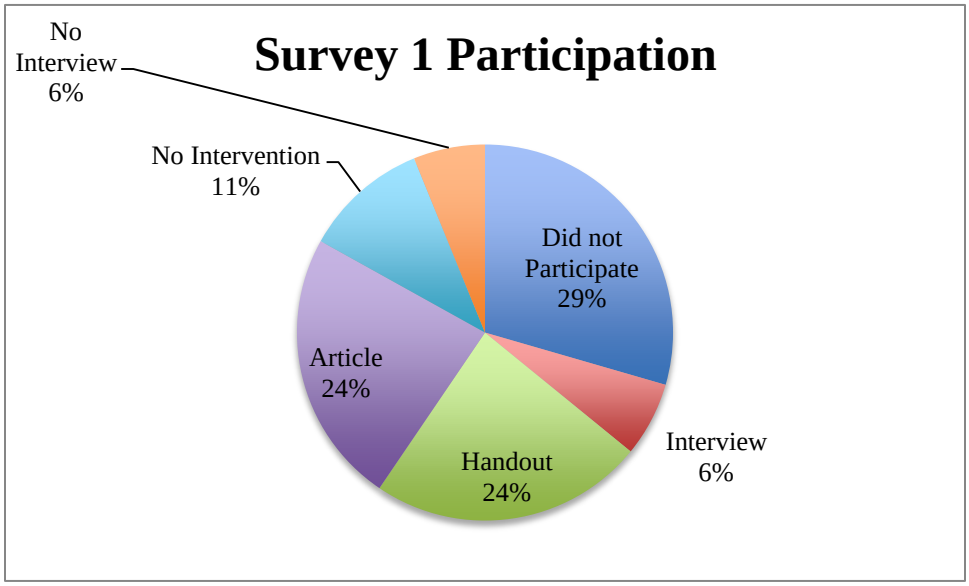
APPENDIX 7.1 **Metacognition Study Data**

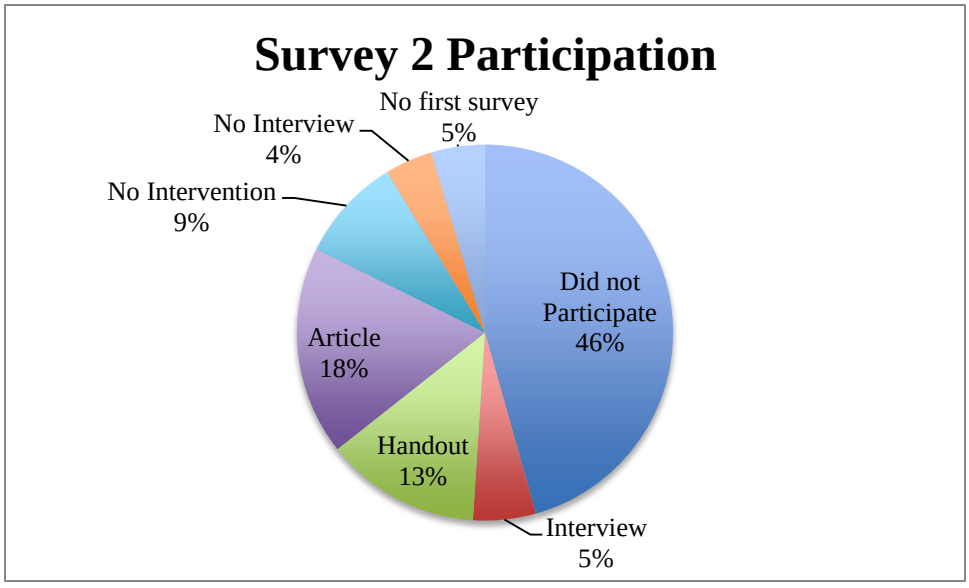


APPENDIX 7.2

Final Participant Data

	Metacognition Survey 1	Metacognition Survey 2
Total Participants	274	211
Percentage that Participated	70.4%	54.2%
Interview	25/47.2%	21/39.6%
Handout	92/60.1%	52/34.0%
Article	92/66.7%	70/50.7%
No Intervention/Control	42/84.0%	35/70.0%
No Interview/Control	24/45.3%	16/30.2%
No First Survey	-	18

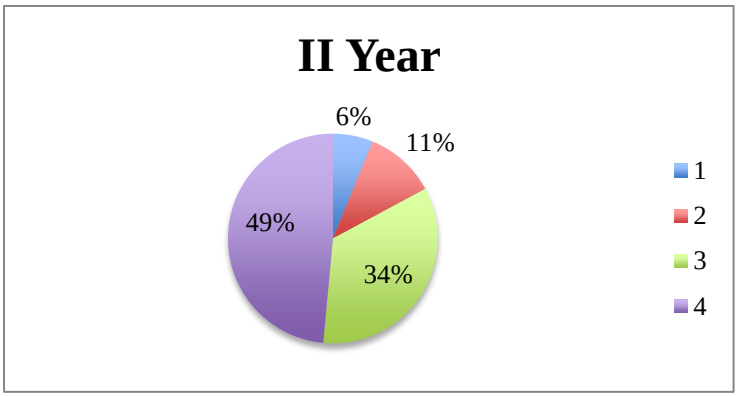


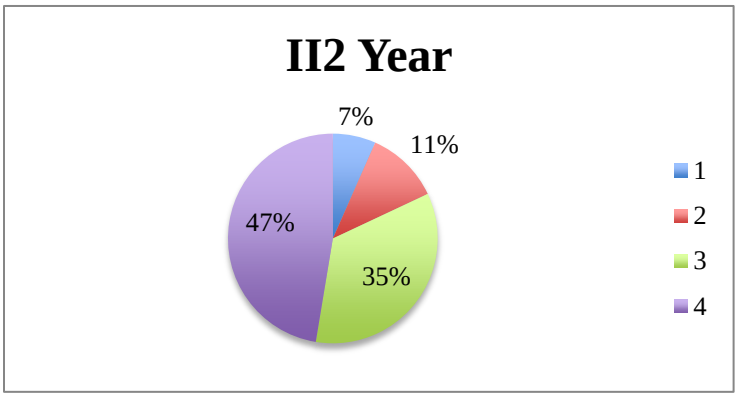


APPENDIX 7.3

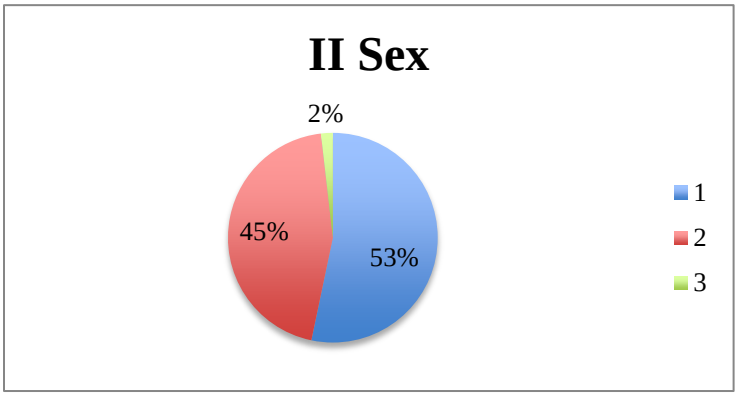
Demographics

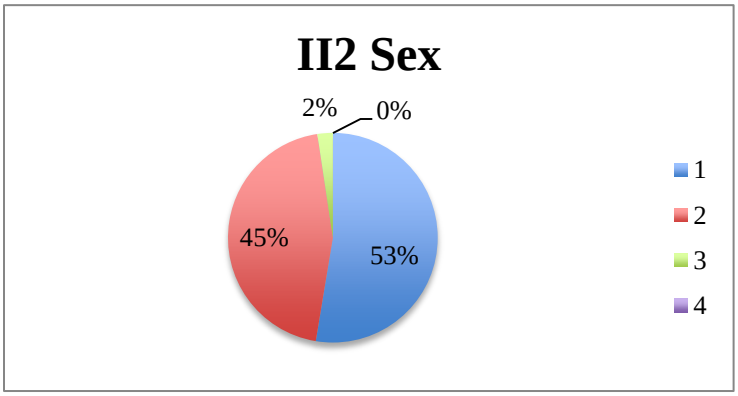
Class Year	Metacognition Survey 1	Metacognition Survey 2
2015	17/6.2%	14/6.6%
2016	30/10.9%	24/11.4%
2017	94/34.3%	73/34.6%
2018	133/48.5%	100/47.4%





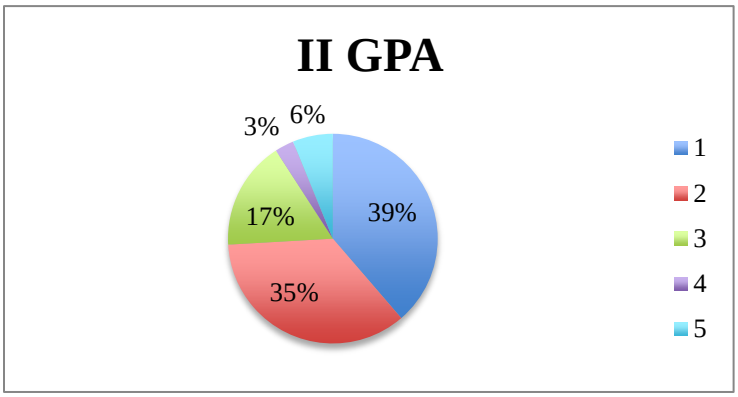
How do you Identify?	Metacognition Survey 1	Metacognition Survey 2
Female	146/53.3%	111/52.6%
Male	123/44.9%	95/45.0%
Prefer not to respond	5/1.8%	5/2.4%

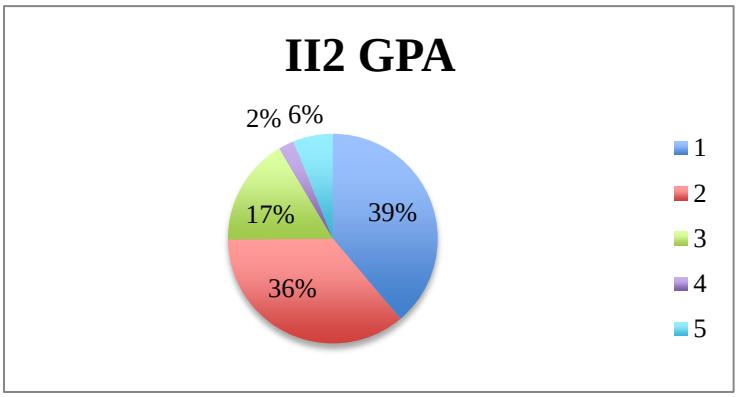




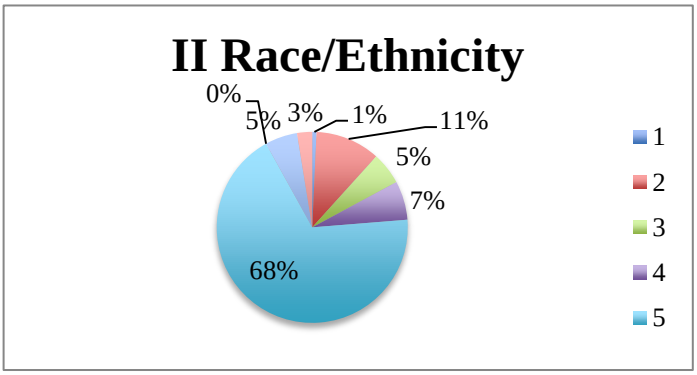
***Note:** 51.5% of students who answered this survey reported that they intended to major in at least one science or math field.

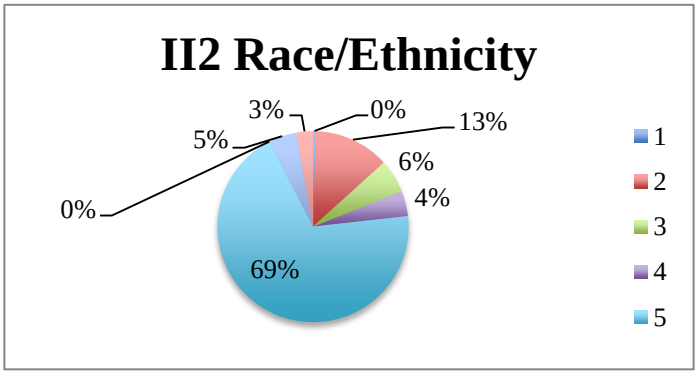
GPA	Metacognition Survey 1	Metacognition Survey 2
4.0-3.5	106/38.7%	82/38.9%
3.49-3.0	97/35.4%	76/36.0%
2.99-2.5	46/16.8%	35/16.6%
2.49-2.0	8/2.9%	5/2.4%
Other/Prefer not to respond	17/6.2%	13/6.2%





How do you Identify?	Metacognition Survey 1	Metacognition Survey 2
American Indian/Native American	2/.7%	1/.5%
Asian	33/12.0%	27/12.8%
Black/African American	15/5.5%	12/5.7%
Hispanic/Latino	17/6.2%	9/4.3%
White/Caucasian	189/69.0%	146/69.2%
Pacific Islander	0/0	0/0
Other	14/5.1%	10/4.7%
Prefer not to respond	8/2.9%	6/2.8%





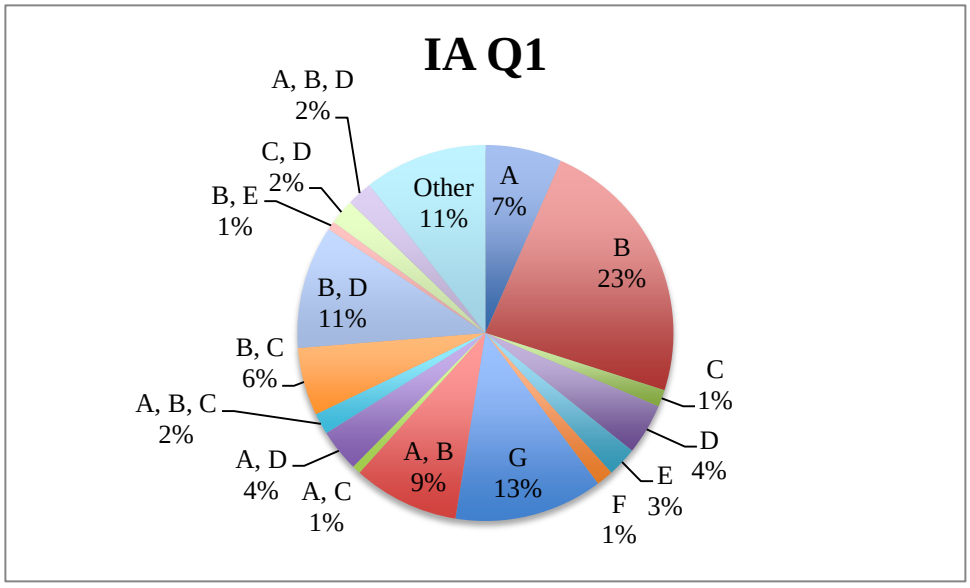
QUESTION
Strongly Agree - 1
Agree - 2
Neutral -3
Disagree - 4
Strongly Disagree - 5

Metacognition Survey 1

Part IA

IA Q1 - Please write a short description of how you would normally go about studying for a test.

Rereading	A
Notes	B
Flashcards	C
Problems	D
Library	E
Group	F
Other	G



Discussion: This data was coded (using the designations below) and analyzed quantitatively. Some students mentioned various methods. This is represented through the coded combination. Many students indicated that they studied using their notes or reread the textbook. Many of the short answers were long and detailed, however, students often used bullet points to indicate the various ways they study; most did not indicate the types of tests or types of subjects they used the described study method for.

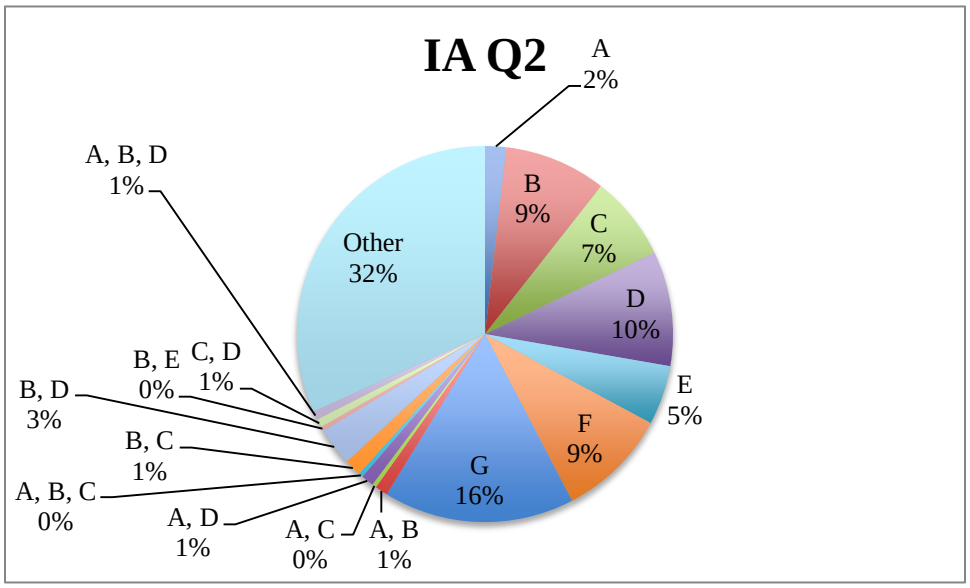
Notable Student Answers:
"I go about studying differently for different types of tests. For science and math classes, I do lots of practice problems, whereas, for other classes I re-read, make notecards and memorize (Chem 120A, Handout, 2017, Undecided Major, Female)"

"I will reread all study materials and highlight the things that I make lease sense to me. These are then signaled not to be studied alone. Once I understand them more I then study them with everything else in context (BIO 102, Handout, 2015, Biology Major, Female)"

"I don't study for tests/classes. This is not a joke. I don't study (PHYS 130A, Article, 2018, Physics Major, Male)."

IA Q2 - Please write a short description of a study method that works the most successfully for you.

Rereading	A
Notes	B
Flashcards	C
Problems	D
Library	E
Group	F
Other	G



Discussion: This data was coded (using the designations below) and analyzed quantitatively. Some students mentioned various methods that were the most successful for them. This is represented through the coded combination. Some students indicated that they studied most successfully the "Same" way that they reported they normally studied. Many of the short answers were long and detailed, however, students often used bullet points to indicate the various ways they study; most did not indicate the types of tests or types of subjects they used the described study method for.

Notable Student Answers:

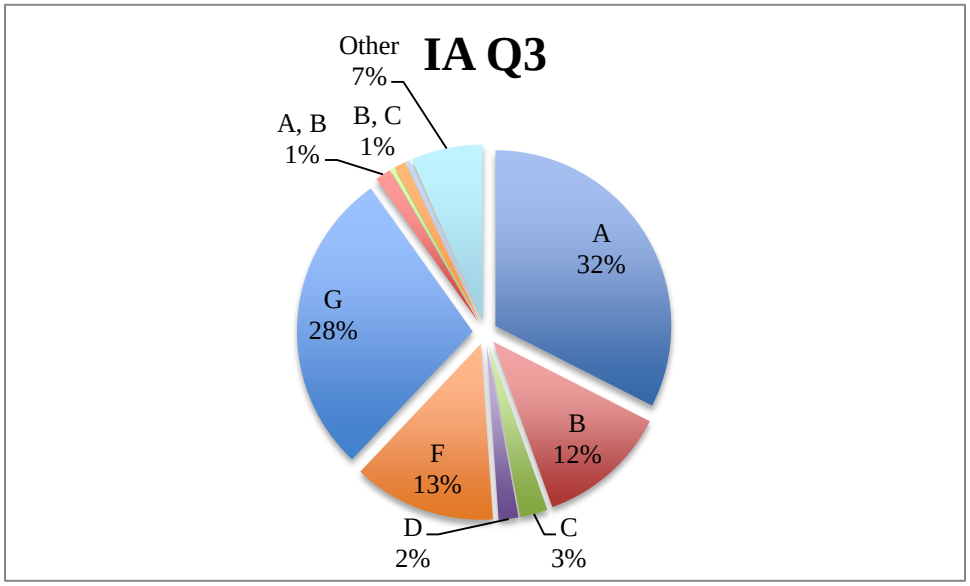
"Associations and correlations between terms as well as quizzing myself without my notes (CSC 121A, Control, 2018, Undecided Major, Male)."

"Studying isn't one of my strong suites. I usually just remember the information (CHEM 130A, Interview, 2017, Biochemistry Major, Male)

"Study ahead (a week or two) before exam, constantly practicing problems for math/science, other subjects read different topics a day/spread out chapters by days (CSC 121A, Article, 2017, Computer Science Major, Male)."

IA Q3 - Please write a short description of a study method that works the least successfully for you.

Rereading	A
Notes	B
Flashcards	C
Problems	D
Library	E
Group	F
Other	G



Discussion: This data was coded (using the designations below) and analyzed quantitatively. Some students mentioned various methods that were the least successful for them. This is represented through the coded combination. Some students indicated that they studied least successfully, but were not clear if this was same or different than the way they normally studied. Many of the short answers were long and detailed, however, students often used bullet points to indicate the various ways they study; most did not indicate the types of tests or types of subjects they used the described study method for.

Notable Student Answers:

"I cannot simply re-read the textbook. That requires less active participation (PSY 100B, Article, 2018, Undecided Major, Female)."

I cannot study with online materials for it is easy to become distracted. Also studying with music on does not aid in retention (PHY 130A, Article, 2018, Physics and Mathematics Major, Male)."

Writing the material over and over again doesn't benefit me too much. I am visual learner so seeing and thinking about the info works better (CHEM 130C, No Interview/Control, 2017, Environmental Geoscience, Male)."

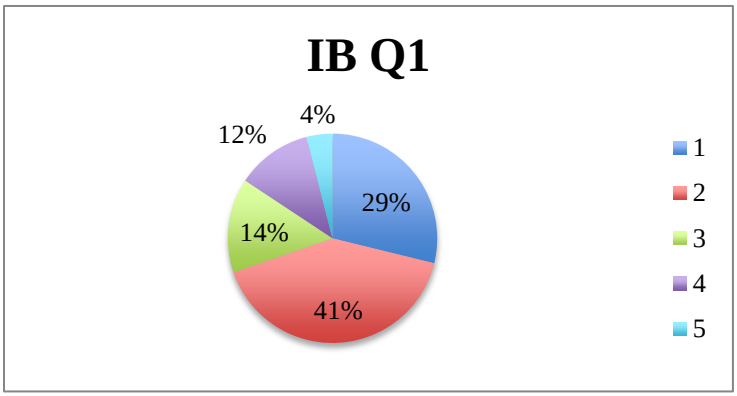
Part IB

Directions – Circle the answer that best reflects your personal position on the following statements.

IB Q1 - I consider myself to be a math and science person.

Strongly Agree Agree Neutral Disagree Strongly Disagree

IB Q1
79
112
40
32
11

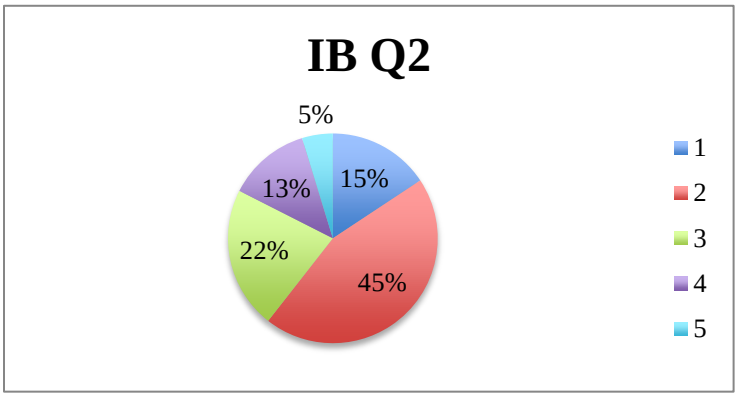


Discussion: The majority of students (41%) agreed that they considered themselves to be a math and science person. 29% of students strongly agreed with this statement. Very few students strongly disagreed or disagreed with this statement, which leads the researcher to conclude that the majority of students enrolled in introductory math and science courses at DePauw consider themselves to be science people. One might speculate that the students who did not consider themselves to be math or science people might be taking the course for a required credit or simply to try out the type of course. Because many of the students in this study have the intentions to major in a math or science field (51.5%), this student perceptions match up with their choice in major.

IB Q2 - I consider myself to be a strong math and science student.

Strongly Agree Agree Neutral Disagree Strongly Disagree

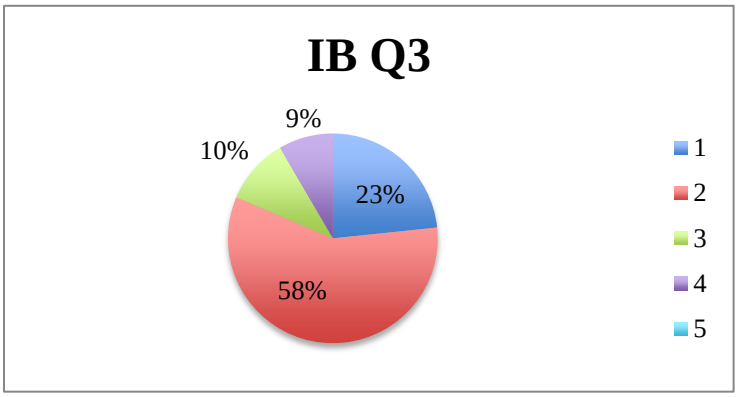
IB Q2
43
123
60
35
13



Discussion: In comparison to the previous question discussing student perceptions of whether or not they are a math and science person, similar percentages of students reported that they Strongly Agreed (15%) and Agreed (45%) that they were a strong math and science person. Most students, however, were Neutral (22%) about this, which could indicate that some are unsure if they are strong students, being in introductory courses. This data might be skewed if indeed this is the student's first introductory math or science course at DePauw, however, most students are operating with the knowledge they have prior to the survey, so the likelihood that they have encountered math and/or science outside of this experience is highly likely.

IB Q3 - I study differently for different types of courses (i.e. Science/Math, Humanities, etc.).

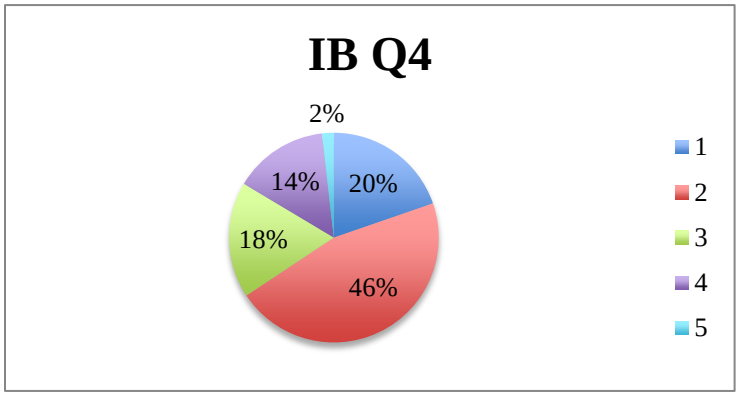
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IB Q3	64	159	28	23	0



Discussion: The majority of students (58%) reported that they study differently for different types of courses. Additionally, 23% of students strongly agreed with this statement, with a combined 19% of students who were Neutral or Disagreed with the statement. No students reported that they Strongly Disagreed that they studied differently for different types of courses. This indicates that students recognize a difference between different subjects; however, it is not guaranteed that this is because of an increased metacognitive awareness, but might instead be a learned activity. However, this question specifically sheds a light on ways that students can relate to metacognition and gain a deeper understanding of it; if they see metacognition working in the habits they already do, they might be more likely to see the importance of metacognition regulation and awareness.

IB Q4 - I study differently for different types of tests (i.e. essay, multiple choice, fill-in, etc.)

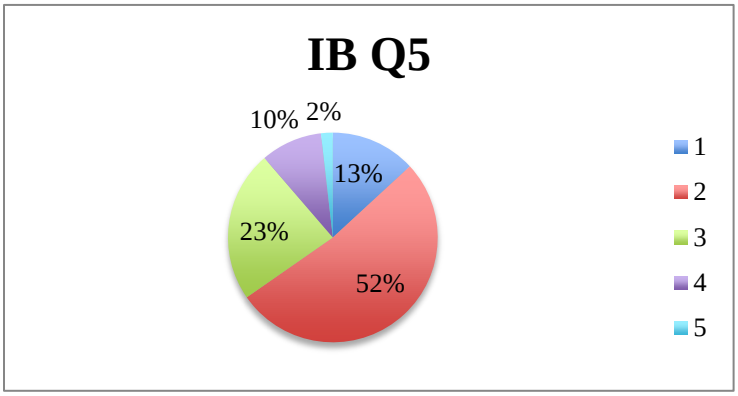
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IB Q4	54	126	49	40	5



Discussion: In comparison to the previous question, similar percentages of students reported that they study differently for different types of tests, however, this had nothing to do with the subject of the type of test. 46% of students reported that they Agreed with this statement and 20% of students Strongly Agreed, leading to the idea that these students recognize a difference between test types and the importance of studying differently for each type (that there is no one true way to study for a test and no one way to study for each test, etc.). Different from the previous question, a combined 16% of students Disagreed or Strongly Disagreed that they study differently for different types of tests, which might be due to the fact that students have set study methods for certain subjects and do not alter their study habits within a subject.

IB Q5 - I study differently for math and science courses, specifically.

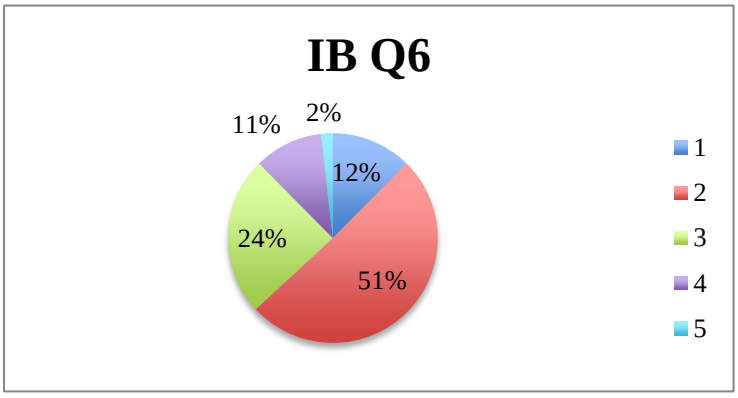
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IB Q5	36	143	64	26	5



Discussion: When asked about math and science courses specifically, 52% of Students Agreed and 13% of students Strongly Agreed that they study differently. Very few students reported that they Disagreed (10%) or Strongly Disagreed (2%), but a higher percentage of students were neutral than in previous questions discussing study habits for different courses. The majority of students, however, did report studying differently, but the students who Agreed in any way (65%) was lower than the percentage who Agreed in any way when asked about studying differently for different types of courses (81%). Students do not seem to set math and science courses apart from other courses, however, it seems that students are more willing to report studying differently for courses more generally, than reporting studying for math and science courses differently. This might be an area of concern for metacognition in terms of math and science if it is found to be consistent in future research.

IB Q6 - I study differently for math and science tests, specifically.

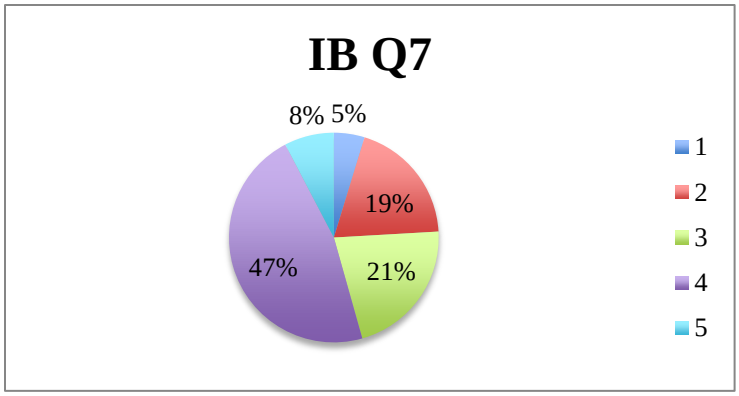
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IB Q6	34	139	67	29	5



Discussion: When asked about studying differently for Math and Science tests, specifically, students reported almost exactly the same as when asked in terms of courses. This might be due to the fact that students assimilate taking tests in math and science with studying for the course more generally, however, it is in conclusive as to why the data is similar.

IB Q7 - I struggle with deciding how to study.

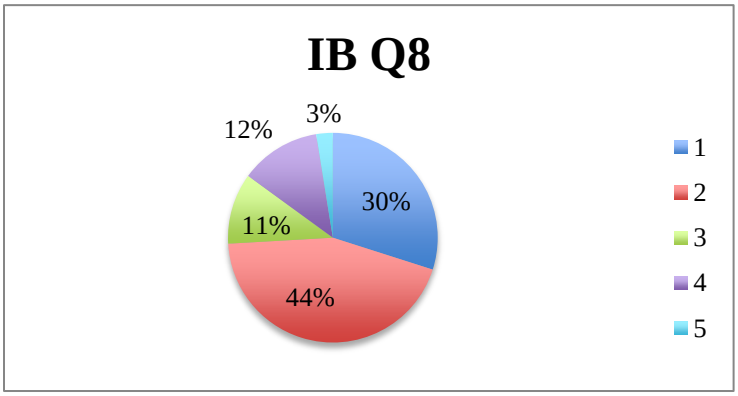
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IB Q7	13	53	59	128	21



Discussion: Asking students about whether they struggled with deciding how to study was done so in the hopes of being able to assess whether students think about changing their study habits, deciding how to study, etc. Only 5% of students Strongly Agreed and 19% of students Agreed that they struggled with how to study. 47% of students Disagreed and 8% of students Strongly Disagreed with this statement. This data suggests that while these students might study differently for different tests and courses, that they do not necessarily struggle with the decision of how to study. Agreement with this statement might expose some test or study anxiety or a lack of awareness or control in terms of metacognitive skills. This data could also reflect student confidence in studying, but is not conclusive as to why students do not report higher agreement with struggling in this way.

IB Q8 - My study habits have changed since entering college.

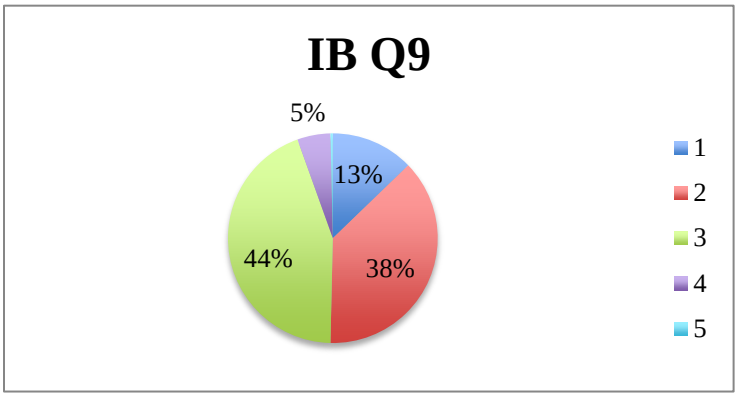
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IB Q8	82	121	30	34	7



Discussion: A combined 74% of students Agreed in some way that their study habits had changed since entering college, while only a combined 15% of students Disagreed in some way that their study habits had changed since high school. This data suggests that students in introductory courses generally experience a shift or change in their study habits in college. Acknowledgement of this shift could lead to higher metacognitive awareness as well as act as support that introductory courses in college are significantly important times for metacognition to be introduced in the classroom (assuming a large amount of first year, respondents).

IB Q9 – I will do well in this course because I know how to study for it.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IB Q9	35	103	121	14	1



Discussion: The majority of students were Neutral (44%) in regards to knowing how to study for a test as being the reason they would do well. This might have been due to the fact that students completed this survey in class and might not have wanted the professor to know the true answer to this question, even though they were ensured that the professor would not receive their survey information. Additionally, it is possible that students might not have known if they would do well in the course, since they had just started it. However, only 5% of students Disagreed in any way, so the statement was truer for more students than it was false.

IB Comments
Discussion: Very few students had comments for this section.

Notable Student Comments:

"Study decisions are based on a case-by-case basis (CHEM 130A, Interview, 2018, Biochemistry Major, Male)."

My study habits are beginning to change. I'm going to try to study more now. I'm doing well now but I can do better if I study harder (CHEM 12A, Handout, 2017, Pre-Engineering Major, Female)."

In the science courses, before I entered college I was a math and science person. But the courses at DePauw are different and harder to where I know the material, but I double guess myself a lot (CHEM 120B, Handout, 2017, Biology and English Major, Female)."

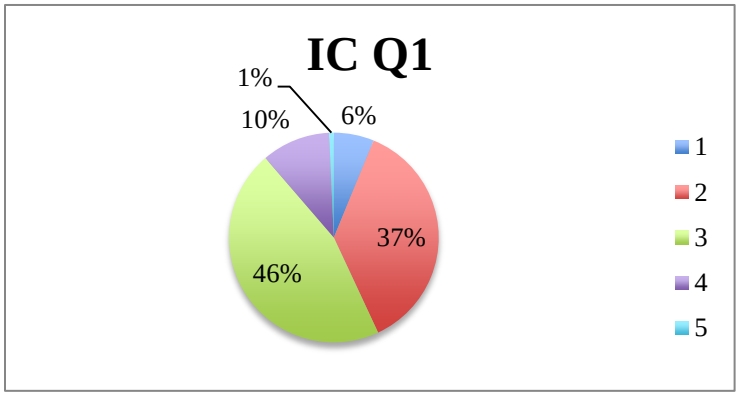
Part IC

Directions – Circle the answer that best reflects your personal position on the following statements.

IC Q1 - I think about how I think and learn.

Always Very Often Sometimes Rarely Never

IC Q1
17
101
125
29
2

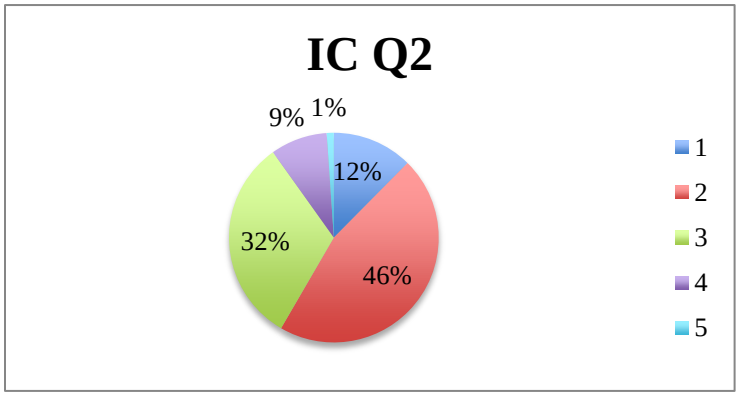


Discussion: The majority of students Sometimes (46%) thought about how they think and learn. This exposes the sad truth that almost half of the students in this study do not even know how often they think about their own thinking (metacognition) or are unable to respond either way. 37% of students reported that they Very Often think about how they think and learn and 6% Always think about how they think and learn. Additionally, a combined 11% of students reported that they Rarely or Never thought about how they think and learn. This lack of thinking about thinking and learning fuels continued study of metacognition and why students do not seem to think about their own thinking processes naturally, or more often than not.

IC Q2 - I think about how my mind works.

Always Very Often Sometimes Rarely Never

IC Q2
34
126
87
24
3

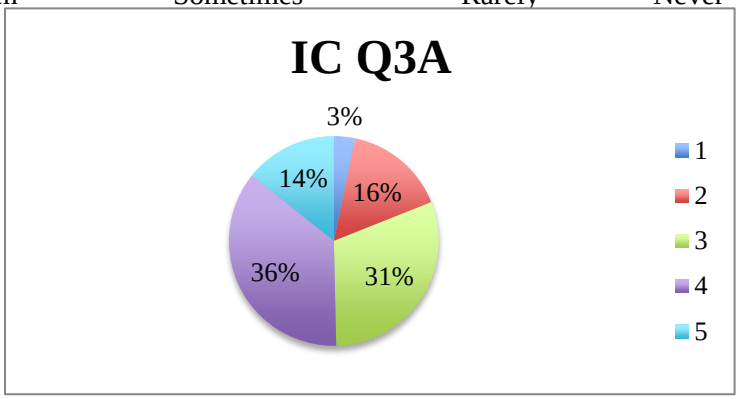


Discussion: Almost exactly the same as the previous question, 10% of students reported that they Rarely or Never think about how their mind works. 46% of students reported Very Often thinking about the way their mind words. 12% of students Always think about how their mind works; this data seems to report a slightly different story in that students are more likely to think about how their mind works than how they think and learn.

IC Q3 - I use the following strategy to study or learn:

IC Q3A - Ex. Rhyme (i.e. to-be-remembered items of information are embedded in a rhyme)

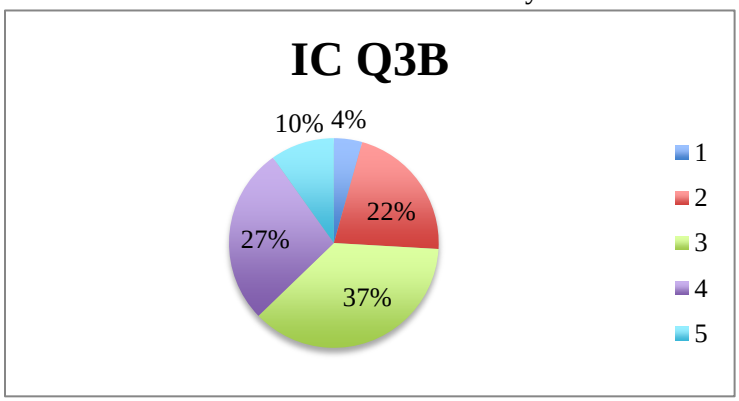
Always	Very Often	Sometimes	Rarely	Never
9	43	84	99	39



Discussion: When asked about the particular study habit of Rhyming, 19% of students reported that they Very Often or Always use Rhyme as a strategy to study or learn. 50% of students, however, reported that they Rarely or Never used Rhyme as a strategy. 31% of students Sometimes used this strategy. This strategy tied as the least used strategy by students.

IC Q3B - Ex. Acronym (i.e. first letter from each to-be-remembered item is used to make a word)

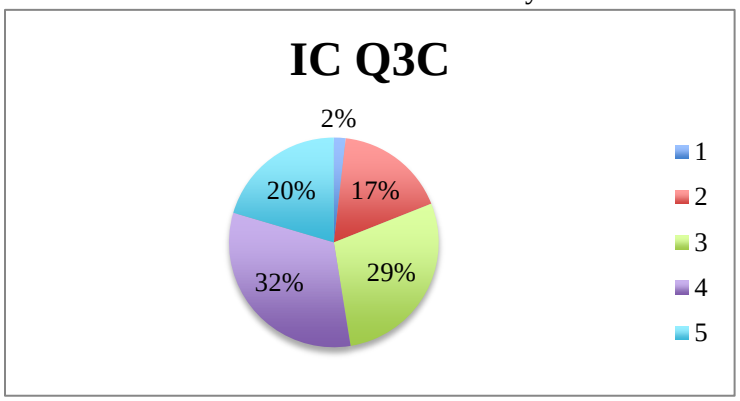
Always	Very Often	Sometimes	Rarely	Never
12	59	101	75	27



Discussion: When asked about the particular study habit of using Acronyms, 26% of students reported that they Very Often or Always use Acronyms as a strategy to study or learn. 37% of students, however, reported that they Rarely or Never used Acronyms as a strategy. 37% of students Sometimes used this strategy.

IC Q3C - Ex. Acrostic (i.e. first letter from to-be-remembered items are used to create a series of words/forms a sentence)

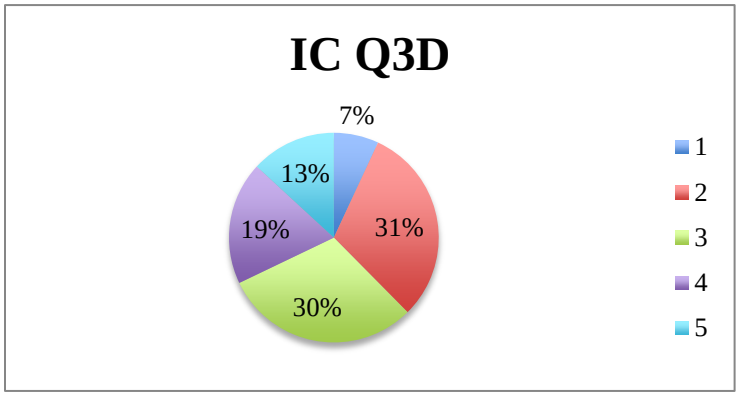
	Always	Very Often	Sometimes	Rarely	Never
IC Q3C	5	47	78	88	56



Discussion: When asked about the particular study habit of using Acrostics, 19% of students reported that they Very Often or Always use Acrostics as a strategy to study or learn. 52% of students, however, reported that they Rarely or Never used Acrostics as a strategy. 29% of students Sometimes used this strategy. This strategy tied as the least used strategy by students.

IC Q3D - Ex. Method of loci (i.e. generate visual images of locations and pair with to-be-remembered items to memorize)

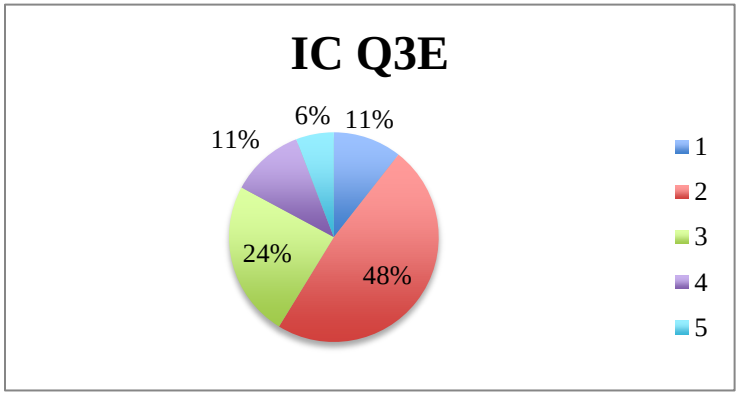
	Always	Very Often	Sometimes	Rarely	Never
IC Q3D	19	84	83	52	36



Discussion: When asked about the particular study habit of using Method of Loci, 38% of students reported that they Very Often or Always use Method of Loci as a strategy to study or learn. 32% of students, however, reported that they Rarely or Never used Method of Loci as a strategy. 30% of students Sometimes used this strategy.

IC Q3E - Ex. Keyword (i.e. create a visual image of a word which links to to-be-remembered item)

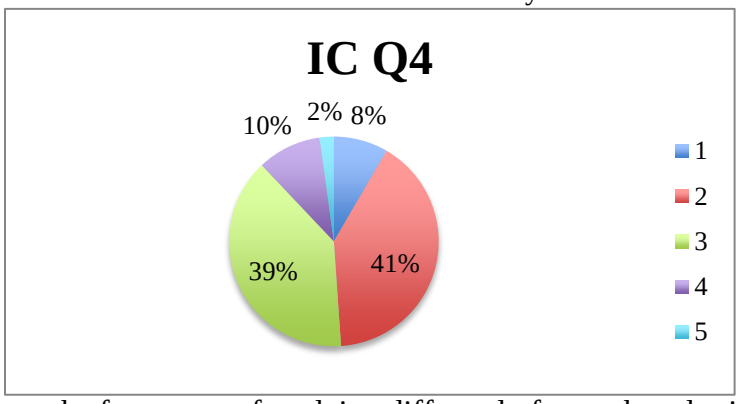
Always	Very Often	Sometimes	Rarely	Never
IC Q3E				
29				
132				
66				
31				
16				



Discussion: When asked about the particular study habit of using Keywords, 59% of students reported that they Very Often or Always use Keywords as a strategy to study or learn. 17% of students, however, reported that they Rarely or Never used Keywords as a strategy. 24% of students Sometimes used this strategy. This was the most used strategy by students.

IC Q4 - I study differently for math and science courses, specifically.

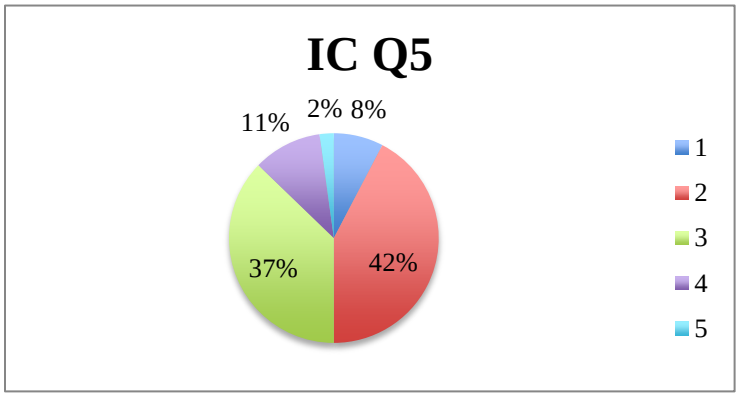
Always	Very Often	Sometimes	Rarely	Never
IC Q4				
23				
111				
107				
27				
6				



Discussion: Asking students about the frequency of studying differently for math and science courses, specifically, 49% of students Very Often or Always studied differently. 12% of students Rarely or Never studied differently and 39% of students Sometimes studied differently for math and science courses. In comparison to the percentages of students who agreed with the statement of studying differently, in IB Q5, 65% of students reported that they studied differently for science and math courses. Even though more students reported that they do study differently for math and sciences courses, they do not do so as frequently. Frequency of studying differently for math and science courses does not necessarily correlate with the act of studying differently for these courses.

IC Q5 - I study differently for math and science tests, specifically.

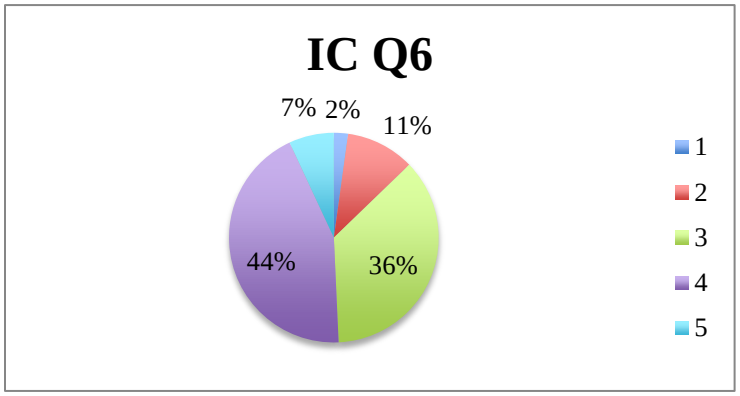
Always	Very Often	Sometimes	Rarely	Never
21	116	102	29	6



Discussion: Asking students about the frequency of studying differently for math and science tests, specifically, 50% of students Very Often or Always studied differently. 13% of students Rarely or Never studied differently and 37% of students Sometimes studied differently for math and science tests. In comparison to the percentages of students who agreed with the statement of studying differently, in IB Q6, 63% of students reported that they studied differently for science and math tests. Even though more students reported that they do study differently for math and sciences tests, they do not do so as frequently. Frequency of studying differently for math and science tests does not necessarily correlate with the act of studying differently for these courses.

IC Q6 - I struggle with deciding how to study for math and science courses and tests.

Always	Very Often	Sometimes	Rarely	Never
6	29	100	120	19



Discussion: Only 13% of the students reported that they Very Often or Always struggle with deciding how to study for math and science courses and tests. Additionally, 51% of students Rarely or Never struggled with this. This is a good sign in that students believe that they know how to study; increased numbers of students struggling with even the decision of how to study would demonstrate major metacognition problems in terms of study habits and knowing "what works" for their science courses and tests.

IC Comments –

Discussion: A few students had comments for this section.

Notable Student Comments:

"I don't really have learning strategies (Chem 130C, Interview, 2018, Biochemistry and Spanish, Female)."

"I am much better on essays than tests, so studying for science/math feels weird (PSY 100D, Article, 2018 English Writing, Female)."

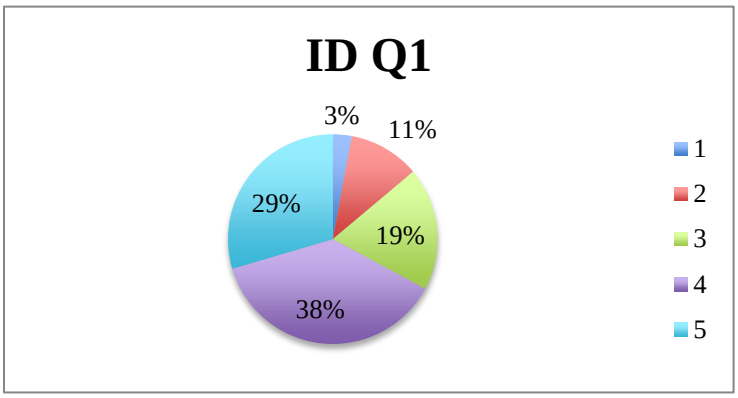
'I know which study tactics are most effective for me, but do not often think about how I think (PHYS 120A, No intervention, 2017, Biochemistry and Spanish, Female)."

Part ID

ID Q1 - What is your level of familiarity with the term "Metacognition" *prior* to this survey?

Very Familiar Familiar Somewhat Familiar Vaguely Familiar Never heard of it

ID Q1
8
30
52
103
81



Discussion: When asked about their familiarity with Metacognition, the focus of this study, only 14% of students reported they were Very Familiar or Familiar with Metacognition. 19% of students were Somewhat Familiar, but 38% of students were Vaguely Familiar (103 students). 29% of students, or 81 students reported they had Never heard of it.

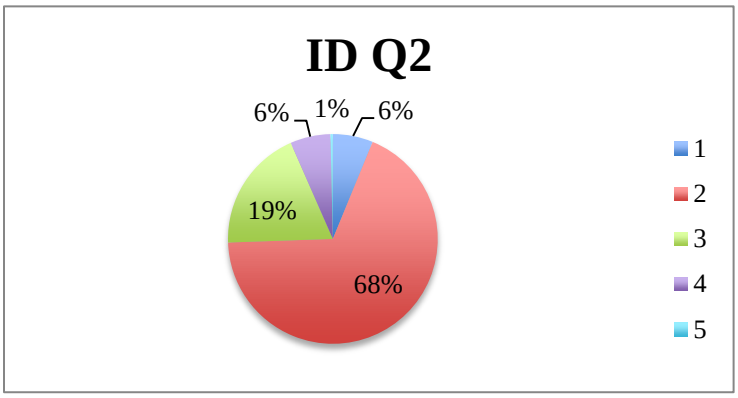
For the purpose of this study, the definition of "Metacognition" is **"the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes."**

Based on this definition, circle the answer that best reflects your personal position on the following statements

ID Q2 - I understand my own thinking processes; I know which study methods work best for me.

Strongly Agree Agree Neutral Disagree Strongly Disagree

ID Q2
17
187
52
17
1

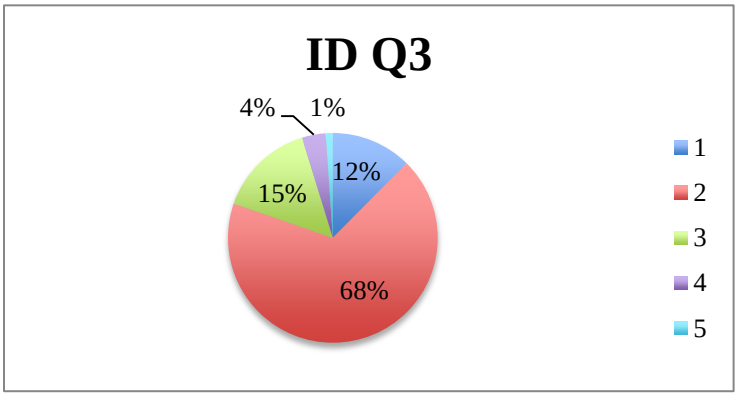


Discussion: When asked about understanding their own thinking process, mirroring the definition of Metacognition given to students, 74% of students Strongly Agreed or Agreed that they did understand their own thinking processes and knew which study methods worked best for them. 19% of students were Neutral and only 7% of students Disagreed or Strongly Disagreed with this statement. This brings to light a student perception that they did understand their own thinking processes, specifically in terms of the Metacognitive awareness/Declarative Knowledge being studied.

ID Q3 - I control my own thinking processes; I choose which study method(s) to use for a task.

Strongly Agree Agree Neutral Disagree Strongly Disagree

ID Q3
34
186
41
10
3



Discussion:.When asked about controlling their own thinking processes, mirroring the definition of Metacognition given to students, 80% of students Strongly Agreed or Agreed that they could control their own thinking processes and knew which study methods to use for a task. 15% of students were Neutral and only 5% of students Disagreed or Strongly Disagreed with this statement. This brings to light a student perception that they can control their own thinking processes, specifically in terms of the Metacognitive regulation/Procedural Knowledge being studied.

ID Comments –

Discussion: Few students had comments for this section.

Notable Student Comments:

"I'm very aware of what I'm capable of and what I'm not capable of (Chem 120A, Handout, 2017, Biology and Pre-medicine Major, Male)."

"A lot of the time I know what habits are best for me, but often I try something different (Chem 120B, Handout, 2017, Biology and English Major, Female)."

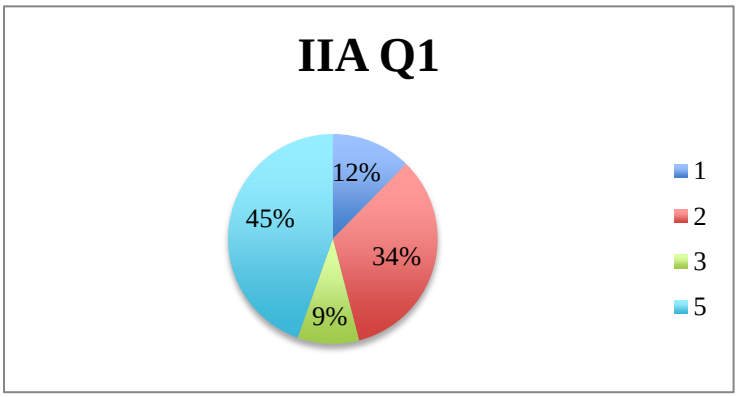
Metacognition Survey 2

Part IA

IIA Q1 - Which of the following interventions was assigned to you?

Handout/ "How-to" Article/10 pgs. Individual Interview No Intervention

IIA Q1
26
71
20
0
94

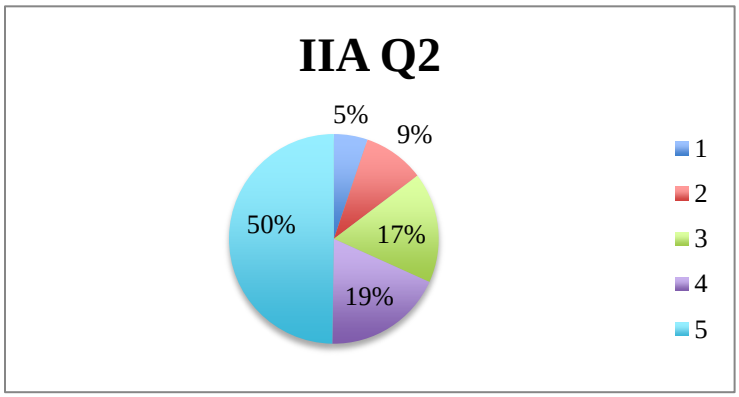


Discussion: When asked about which of the interventions they were assigned, 12% of students reported receiving the Handout (should have been 24.6%), 34% reported receiving the Article (should have been 34%), 9% reported receiving the individual interview (should have been 9%), and 45% reported no intervention (should have been 21%). This data shows that some students receiving the handout did not remember the handout or thought that they were in the no intervention group. Additionally, this shows that students receiving the article remembered receiving it. Students receiving the interview intervention also remembered their intervention type.

IIA Q2 - To which degree did you utilize and take advantage of your intervention?

Fully Mostly Partially Little to None None

IIA Q2
11
20
36
39
105



Discussion: When ask about how much they utilized their assigned intervention, 5% of students reported taking full advantage of the intervention, 9% Mostly took advantage of it, 17% Partially took advantage of it and 19% took little to no advantage of it. Surprisingly, however, 50% of students reported taking No advantage or usage of their intervention. This speaks to the student motivation aspect of learning in that the students were not as motivated to work on their metacognition skills, or any skills for that matter because they didn't take advantage of the intervention. However, many students who did not receive an intervention reported that they took No advantage, however, this data skews the total and should be kept in mind.

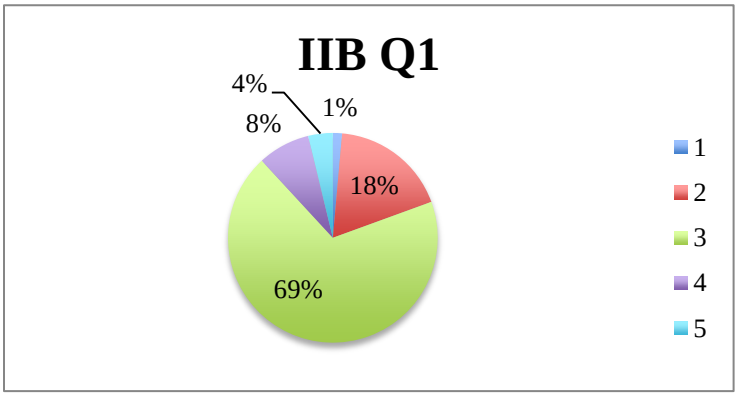
Part IB

Directions – Circle the answer that best reflects your personal position on the following statements.

IIB Q1 - The intervention circled above was helpful.

Strongly Agree Agree Neutral Disagree Strongly Disagree

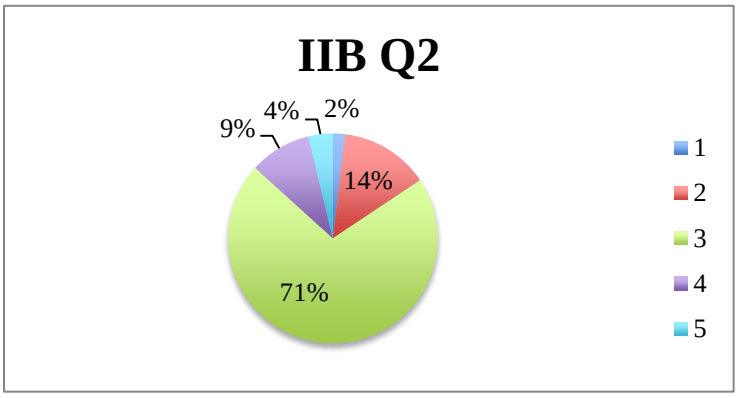
IIB Q1
3
38
145
17
8



Discussion: When asked whether the intervention they were assigned and did or did not take advantage of, 1% of students Strongly Agreed, 18% of students Agreed, 8% of students Disagreed, and 4% of students Strongly Disagreed that their intervention was helpful. The majority of students, 69%, were Neutral when asked if the intervention was helpful. From this data, it is clear that students did not think their interventions were helpful, did not have an intervention to gauge helpfulness or did not know what to say in regards to intervention helpfulness.

IIB Q2 - The intervention circled above was effective.

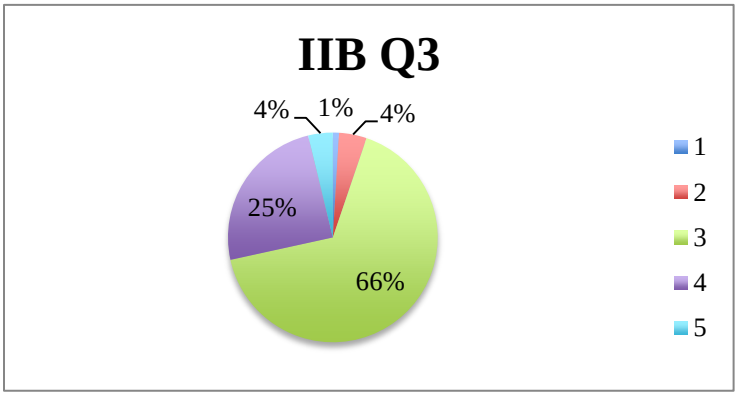
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IIB Q2	4	29	150	20	8



Discussion: When asked whether the intervention they were assigned and did or did not take advantage of, 2% of students Strongly Agreed, 14% of students Agreed, 9% of students Disagreed, and 4% of students Strongly Disagreed that their intervention was effective. The majority of students, 71%, were Neutral when asked if the intervention was effective. From this data, it is clear that students did not think their interventions were effective, did not have an intervention to gauge effectiveness or did not know what to say in regards to intervention effectiveness. While this one question single-handedly addresses the question of this entire thesis, it is important to note that the information that can be gained from the other questions as well as the fact that these interventions might not have been implemented to their fullest.

IIB Q3 - The intervention circled above was a waste of time.

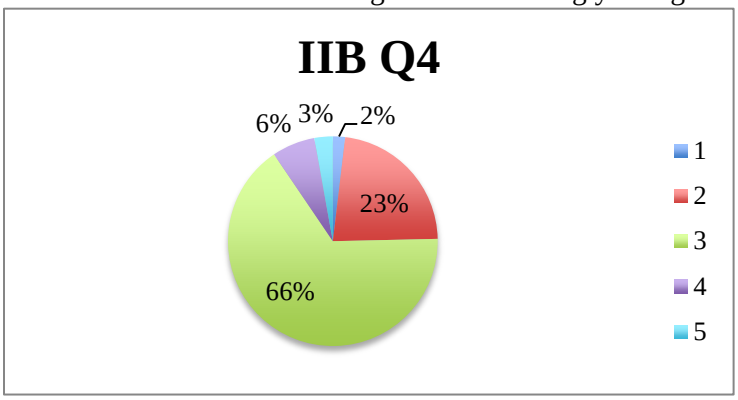
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IIB Q3	2	9	140	52	8



Discussion: When asked whether the intervention they were assigned and did or did not take advantage of, 1% of students Strongly Agreed, 4% of students Agreed, 25% of students Disagreed, and 4% of students Strongly Disagreed that their intervention was a waste of time. The majority of students, 66%, were Neutral when asked if the intervention was a waste of time. From this data, most students did not think the intervention was a waste of time, however, when stacked with other questions, it becomes clearer that the students didn't necessarily think that it was worth their time/effective/helpful either.

IIB Q4 - The intervention circled above helped me to understand metacognition.

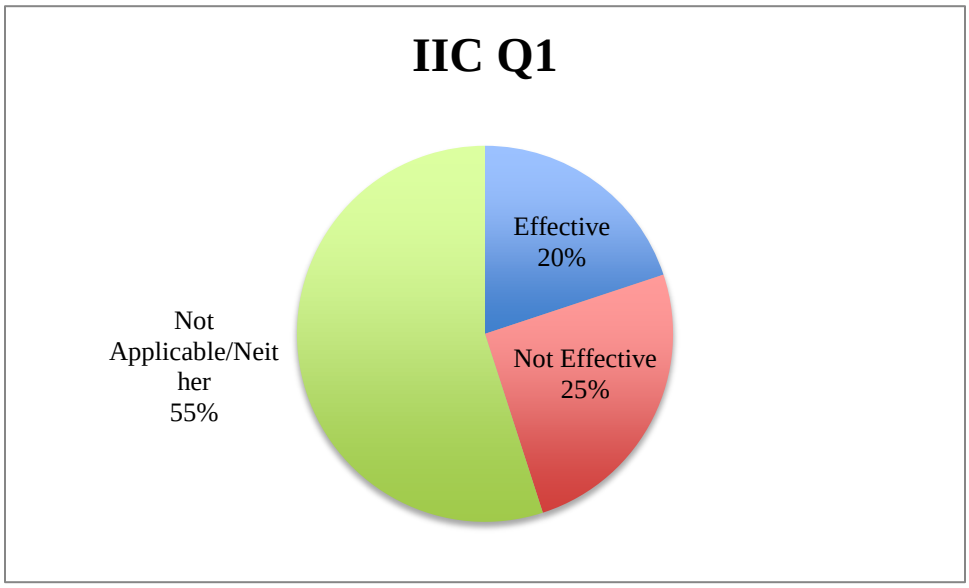
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IIB Q4	4	48	139	14	6



Discussion: When asked whether they thought the intervention helped them to understand metacognition, 25% of students Agreed in some way, 66% of students were Neutral, and only 9% of students Disagreed in some way. This data shows that while most students might not have been sure of whether the intervention helped them, or did not notice the effect, that there was more of a positive response to this study than negative. This is extremely good because it tells that the risk or learning the wrong things or student misunderstanding of the intentions of the study or message of the surveys was minimized. It is important for the researcher that these trials of instruction did not present a deleterious experience for students.

IIC Q1 - In you own words, was your intervention effective or not effective? Why?

All Interventions:	
Effective	42
Not Effective	53
Not Applicable/Neither	116
Interview Intervention:	
Effective	14
Not Effective	6
Not Applicable/Neither	0
Handout Intervention:	
Effective	7
Not Effective	17
Not Applicable/Neither	28
Article Intervention:	
Effective	17
Not Effective	28
Not Applicable/Neither	26
No Intervention/No Interview:	
Effective	4
Not Effective	1
Not Applicable/Neither	46
No first survey:	
Effective	0
Not Effective	1
Not Applicable/Neither	15



Discussion: Most of the students reported that they did not take advantage of the intervention or did not remember receiving one to take advantage of. For this reason, most of the students reported that this question was not applicable or that the intervention was neither effective nor ineffective. The largest number of students (17) to see their intervention as effective was the Article Intervention group. The highest percentage of students (70%) to see their intervention as effective was the Interview group.

IIC Q2 - What would you have changed about your intervention to make it more effective?

Discussion: Many of the students did not offer an answer for this question or left it blank. Some students simply put "Nothing." Students in the Interview group mentioned that they would have liked the interviewer to give an analysis of what they were saying instead of just asking questions. Participants in the handout group said they wanted more examples and ideas of how to implement metacognition. Participants in the article group said they wanted more examples but wanted the article to be shorter. Participants without an intervention wanted at least some intervention and students in the No first survey group did not have a response to this.

Notable Student Answers:

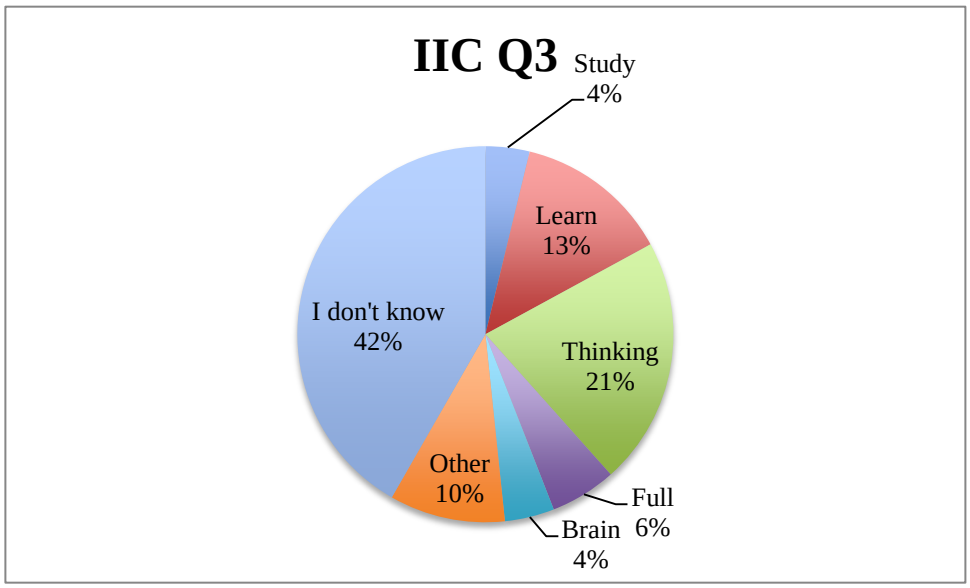
"Make is something more unique/memorable, reading a handout is the the most effective method for leaving an impact (GEOS 117A, Handout, 2018, Undecided, Male)."

"Maybe we could have talked about more study tips other people have tried, or discussed your personal view of the effectiveness of certain study tips (CHEM 130C, Interview, 2018, Biochemistry, Female)."

"Give incentives to read it (CSC 121A, Article, 2018, Undecided, Male)."

IIC Q3 - What is your personal definition of "Metacognition?"

Study	8
Learn	28
Thinking	45
Full	12
Brain	9
Other	21
I don't know	88



Discussion: 58% of the students were able to give some sort of personal definition that connected with the study's definition of metacognition. While all participant definitions were not complete or exact, each of the coded answers reflect a certain portion of the study's metacognition definition. The data shows that this majority of students were able to offer a personal definition of metacognition, even though only 14% of students reported being Familiar or Very Familiar with metacognition in the pre-intervention survey.

Notable Student Answers:

"Awareness of the mental process which one learns, stores, and recalls information (CSC 121A, No Intervention, 2017, Piano Performance Major, Male)."

"The ability for a person to be aware of how one studies/way their brain works best (PSY 100B, Article, 2016, Undecided Major, Male)."

"Metacognition is the self-awareness of how you think in certain subjects (CHEM 130B, Interview, 2017, Geology Major, Female).

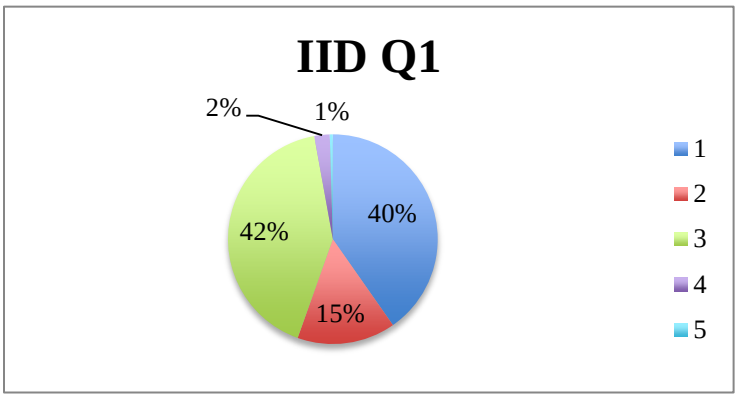
Part ID

Directions – Circle the answer that best reflects how your personal position on the following statement has ***changed since the first survey.***

IID Q1 - I study differently for different types of courses (i.e. Science/Math, Humanities, etc.).

More true | Less false | Same | Less true | More false

IID Q1
85
32
88
5
1

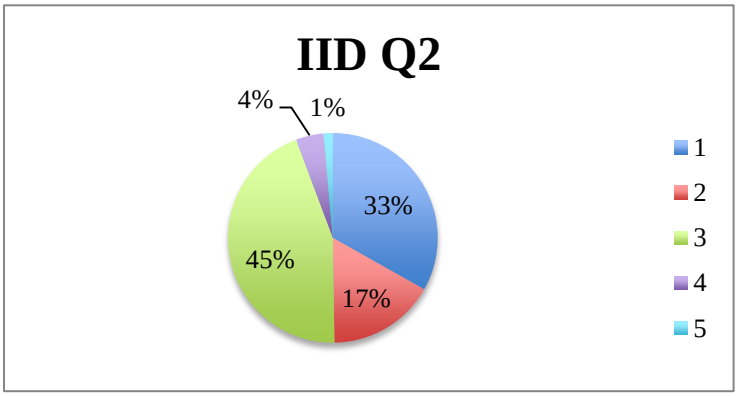


Discussion: When asked about the change they experienced since the first survey, 40% of students reported that it was More True that they study differently for different types of courses, 15% reported it was Less False, 2% reported it was Less True, and 1% reported it was More False. However, 42% of the students reported that they studied the Same as they did before in terms of studying differently for different types of courses. The majority of Same, or no change gives an insight that many of the students were not affected by the study, however, a close second majority of More True illustrates some effectiveness of the survey/interventions.

IID Q2 - I study differently for math and science courses, specifically.

More true | Less false | Same | Less true | More false

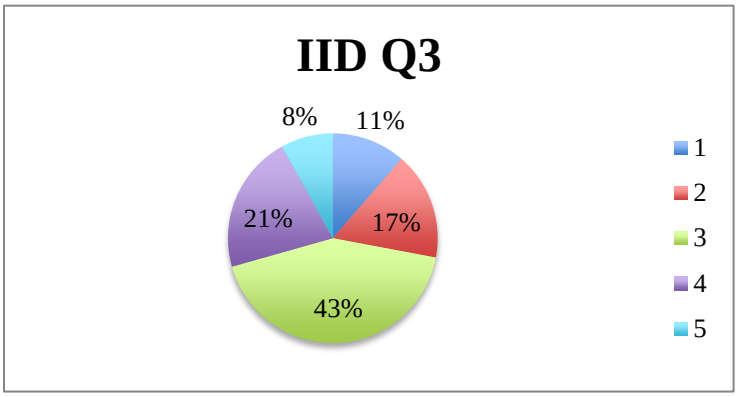
IID Q2
70
35
94
9
3



Discussion: When asked about the change they experienced since the first survey, 33% of students reported that it was More True that they study differently for math and science courses, specifically, 17% reported it was Less False, 4% reported it was Less True, and 1% reported it was More False. However, 45% of the students reported that they studied the Same as they did before in terms of studying differently for math and science courses. This data explains that most students kept their previous study habits in terms of math and science but doesn't completely rule out the idea that metacognition regulation could still be helpful for these math and science students.

IID Q3 - I struggle with deciding how to study.

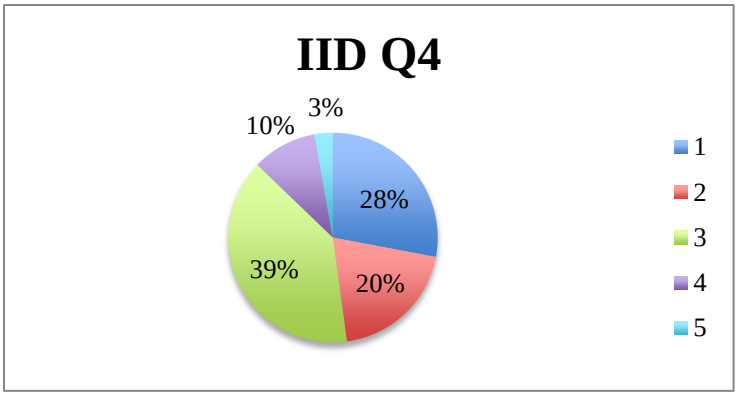
More true	Less false	Same	Less true	More false
24	35	90	45	17



Discussion: When asked about the change they experienced since the first survey, 11% of students reported that it was More True that they struggled with deciding how to study, 17% reported it was Less False, 21% reported it was Less True, and 8% reported it was More False. However, 43% of the students reported that they were the Same in terms of struggling or not struggling with deciding how to study. In comparison to question IB Q6, which asked students to which degree they struggled with deciding how to study during the first survey, the percentage of students who Agreed in any way was 13%, and Disagreed in any way was 51%. It seems that now, there have been minimal changes to these original student perceptions of struggling to decide how to study. This change expresses some shifting in study habits that might be due to the study or from learning about metacognition/thinking about study habit effectiveness. This data could also be due to the fact that students did not remember what they put on their first survey, or did not take the first survey (making the Same percentage higher because of lack of knowing what to indicate).

IID Q4 - I think about how I think and learn.

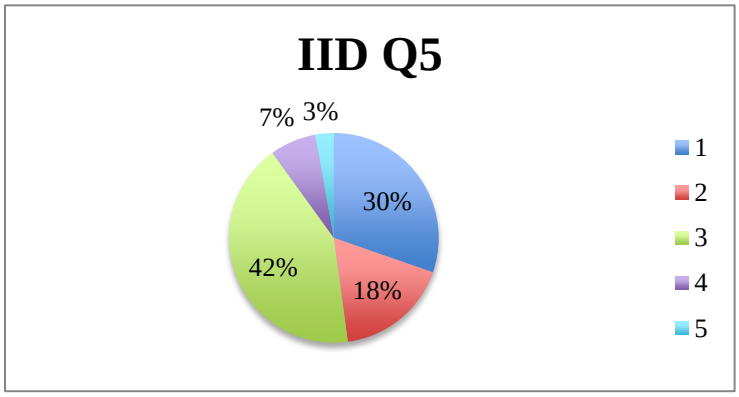
More true	Less false	Same	Less true	More false
59	42	83	21	6



Discussion: When asked about the change they experienced since the first survey, 28% of students reported that it was More True that they think about how they think and learn, 20% reported it was Less False, 10% reported it was Less True, and 3% reported it was More False. However, 39% of the students reported that they were the Same in terms of thinking about how they think and learn. In comparison to question IC Q1, which asked students to which degree they thought about how they think and learn during the first survey, the percentage of students who Agreed in any way was 43%, and Disagreed in any way was 11%. It seems that now, there have been minimal changes to these original student perceptions of struggling to decide how to study. 46% of the students in the first survey, however, reported that they Sometimes thought about how they think and learn. From this data, it seems as though more students think about how they think and learn post-intervention than pre-intervention.

IID Q5 - I think about how my mind works.

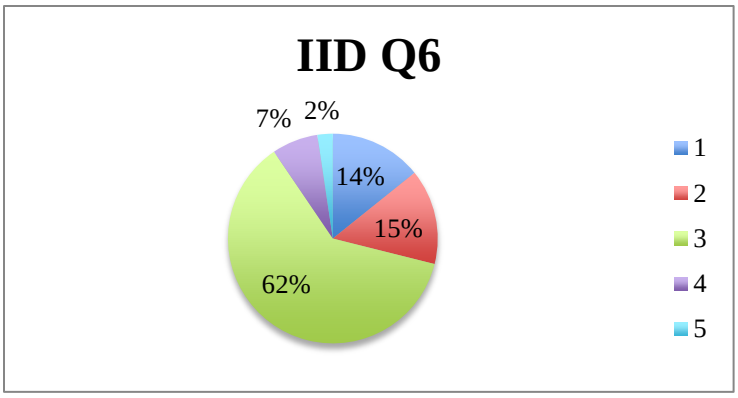
More true	Less false	Same	Less true	More false
64	37	89	15	6



Discussion: When asked about the change they experienced since the first survey, 30% of students reported that it was More True that think about how their mind works, 18% reported it was Less False, 7% reported it was Less True, and 3% reported it was More False. However, 42% of the students reported that they were the Same in terms of thinking about how their mind works. In comparison to question IC Q2, which asked students to which degree they thought about how they think and learn during the first survey, the percentage of students who Agreed in any way was 58%, and Disagreed in any way was 10%. It seems that now, there have been minimal changes to these original student perceptions of struggling to decide how to study. 32% of the students in the first survey, however, reported that they Sometimes thought about how their mind works.

IID Q6 - I use metacognition.

More true	Less false	Same	Less true	More false
30	31	130	15	5



Discussion: When directly asking students whether or not they use metacognition in comparison to before the first survey, 14% of the students More true, 15% of the students Less False, 7% of the students Less True, and 2% of the students More False that they use metacognition. 62% of the students, however, reported that they used metacognition the Same as they did before. While the researcher did not ask students to what extent they used metacognition prior to the first survey, this question assesses whether students think they use metacognition more or not. Most of the students, however, believe that they use it the same amount. This could be because they are unsure if they use it, however, 29% of students combined, reported that using metacognition was More True or Less False, signifying some positive change in terms of use of metacognition.

IID Comments –

Discussion: Very few students had comments for this section.

Notable Student Comments:

"I have tried to study differently, but I don't know how (CHEM 130A, Interview, 2017, Geoscience Major, Female)

"After first survey, I thought more about my thinking and did attempt to manipulate it (CHEM 130 A, Interview/Control, 2017 Undecided Major, Male)."

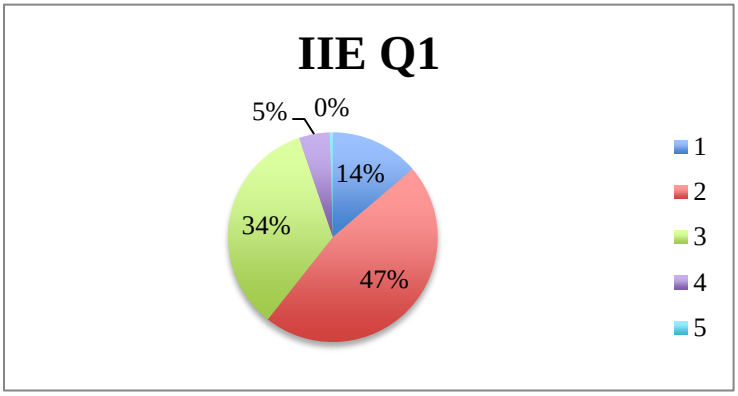
"I usually figure out how to study after the first exam (PSY 100D, No first survey, 2017, Computer Science, Male)."

Part IE

Directions – Circle the answer that best reflects how the following quote applies to you.

IIE Q1 - "I think therefore I am."

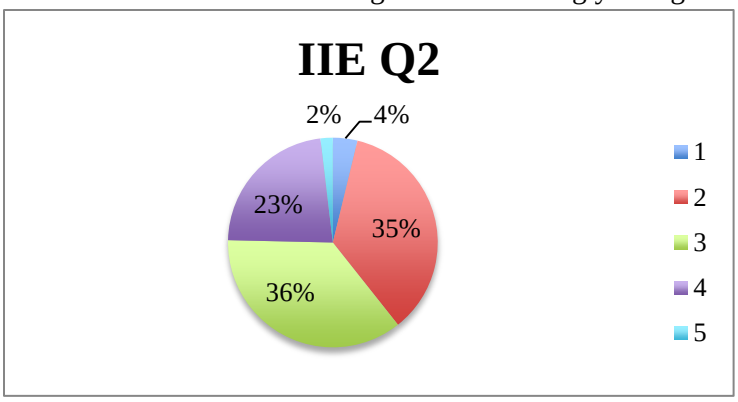
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
29	99	72	10	1



Discussion: Using metacognitively-focused quotes and phrases from famous philosophers and authors, the researcher asked participants the extent to which the quote applied to them personally. This was an attempt to capture the student's perception of their own metacognition, as well as the way they view thinking and learning. 61% of students Agreed in some way and 5% of students Disagreed in some way with 34% of students remaining Neutral. This shows that the majority of students see thinking as constitution of their being. This quote is also one of the most famous ones of the quotes chosen, which means some of the student answers might be based on familiarity, rather than agreement with how the quote applies to them.

IIE Q2 – "Imagination is more important than knowledge."

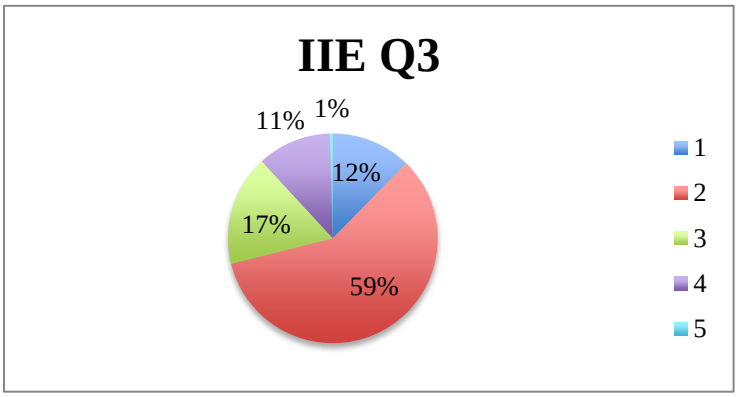
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IIE Q2	8	75	76	48	4



Discussion: Using metacognitively-focused quotes and phrases from famous philosophers and authors, the researcher asked participants the extent to which the quote applied to them personally. This was an attempt to capture the student's perception of their own metacognition, as well as the way they view thinking and learning. 39% of students Agreed in some way and 25% of students Disagreed in some way with 36% of students remaining Neutral. This shows that the majority of students see imagination and what occurs inside of their mind as more important than the knowledge, or what is normally seen as the product of knowing or thinking. However, students might have interpreted this quote as imagination/creativity being more important than knowledge. In both cases, however, there is an increased usage of metacognition or thinking about thinking in order to make a decision of which is more important and how the knower knows which is more important to them.

IIE Q3 - "Students can learn to think better if schools concentrate on teaching them how to do so."

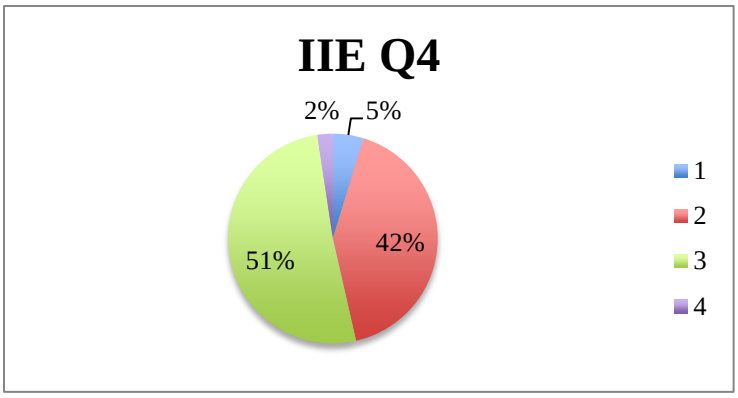
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IIE Q3	26	124	36	24	1



Discussion: Using metacognitively-focused quotes and phrases from famous philosophers and authors, the researcher asked participants the extent to which the quote applied to them personally. This was an attempt to capture the student's perception of their own metacognition, as well as the way they view thinking and learning. 71% of students Agreed in some way and 11% of students Disagreed in some way with 17% of students remaining Neutral. This shows that the majority of students think that students learn better and in application to themselves, they learn better if schools concentrate on teaching them how to. This shows student support for interventions and instruction in the classroom that teaches students how to learn to think better.

IIE Q4 - "Cognitive strategies are used to help achieve a particular goal while metacognitive strategies are used to ensure that the goal has been reached."

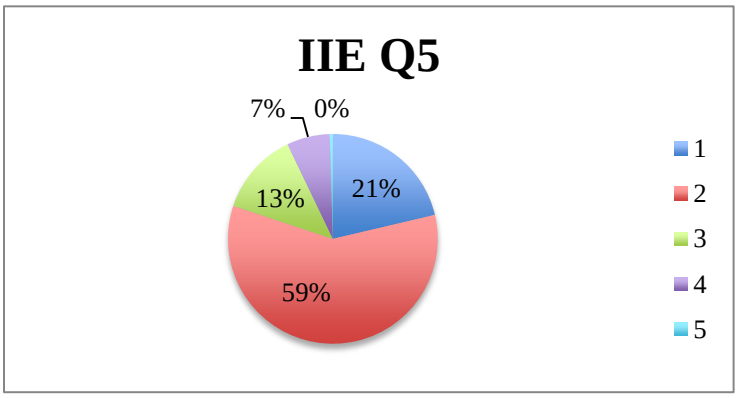
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IIE Q4	10	88	108	5	0



Discussion: Using metacognitively-focused quotes and phrases from famous philosophers and authors, the researcher asked participants the extent to which the quote applied to them personally. This was an attempt to capture the student's perception of their own metacognition, as well as the way they view thinking and learning. 47% of students Agreed in some way and only 2% of students Disagreed in some way. 36% of students remained Neutral. This shows that the majority of students agree that this distinction between cognitive and metacognitive strategies applies to them, but also that very few students disagree with this statement's application to their own person. However, over half of the students remained neutral, which could signify that many of them did not know what they felt about the statement or did not know if it applied to them.

IIE Q5 - "To read without reflecting is like eating without digesting."

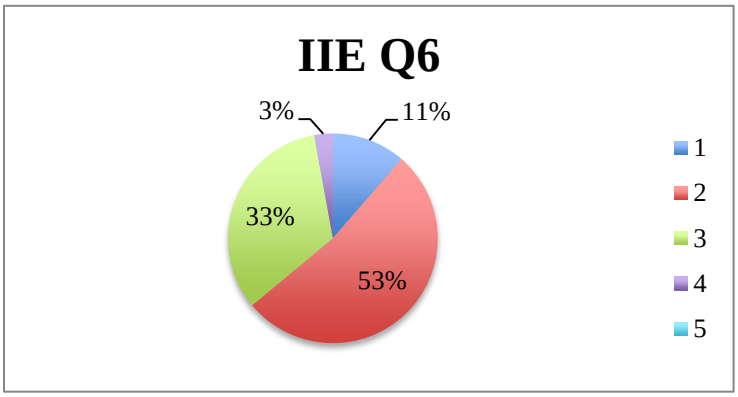
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IIE Q5	45	124	27	14	1



Discussion: Using metacognitively-focused quotes and phrases from famous philosophers and authors, the researcher asked participants the extent to which the quote applied to them personally. This was an attempt to capture the student's perception of their own metacognition, as well as the way they view thinking and learning. 80% of students Agreed in some way and 7% of students Disagreed in some way with 13% of students remaining Neutral. This shows that the majority of students think that reading without reflection is not what they do; reflecting is important to these students. Over 80% of students felt this way and reflecting is an important part of metacognition in that it allows the learner to think about what they read in the same way that they could then think about their own thinking skills.

IIE Q6 - "To make an individual metacognitively aware is to ensure that the individual has learned how to learn."

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
24	111	70	6	0



Discussion: Using metacognitively-focused quotes and phrases from famous philosophers and authors, the researcher asked participants the extent to which the quote applied to them personally. This was an attempt to capture the student's perception of their own metacognition, as well as the way they view thinking and learning. 64% of students Agreed in some way and 3% of students Disagreed in some way with 33% of students remaining Neutral. This shows that the majority think that metacognition allows an individual the insurance that he or she has learned how to learn. Agreement with this statement's applicability with the student's self, sheds a light on the idea that students agree that metacognition is the key for learning how to learn and thinking how to think.

IIE Comments –

Discussion: Very few students had comments for this section.

Notable Student Comments:

"I think that if you don't comprehend what you read there was no purpose to reading (PSY 100B, Article, 2017, Economics Major, Male)."

"Same because I did not read the article (PSY 100D, Article, 2017, Music Performance Major, Female)."

I honestly don't remember what I put before but all my habits are the same (CSC 121A, No Intervention, 2017, Economics, Female)."

Part IF

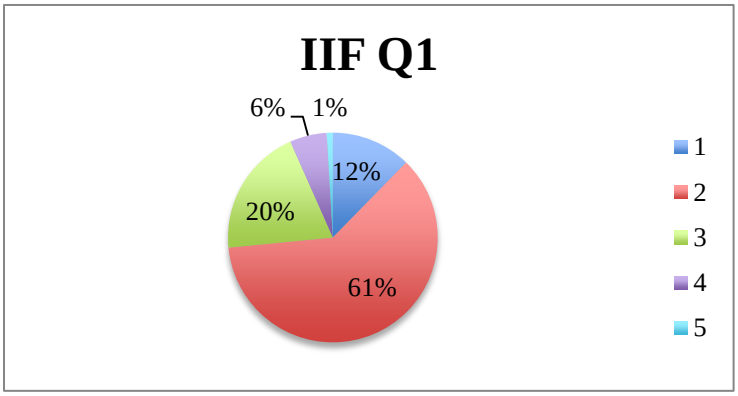
For the purpose of this study, the definition of "Metacognition" is **"the awareness of one's own knowledge and one's ability to understand, control, and manipulate one's cognitive processes."**

Based on this definition, circle the answer that best reflects your personal position on the following statements.

IIF Q1 - I understand my own thinking processes.

Strongly Agree Agree Neutral Disagree Strongly Disagree

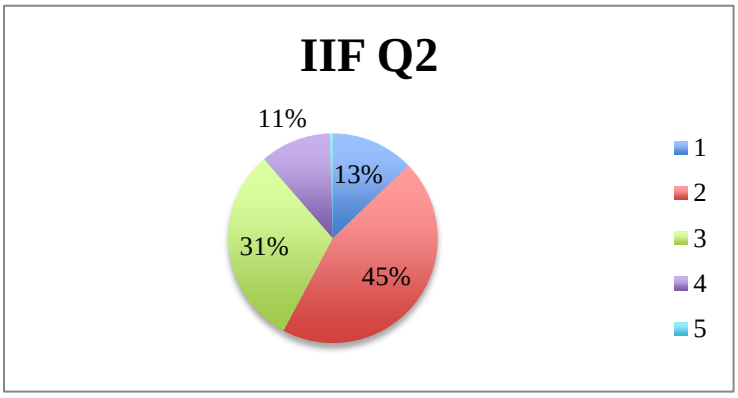
IIF Q1
26
129
42
12
2



Discussion: When asking students again about understanding of their own thinking process, mirroring the definition of Metacognition given to students, 12% of students Strongly Agreed that they understood their own thinking process, similar to the 13% expressed in the pre-intervention survey (ID Q2). 61% of students Agreed, which was a significant increase from the 45% in the pre-intervention survey. 20% of students in the post, and 31% of students in the pre-intervention reported being neutral when asked if they understand their own thinking process. Only 7% of students Disagreed in any way, decreased from the 11% of students who Disagreed pre-intervention. This increase in student perception of understanding their thinking processes shows that there has been an increase in students thinking about their thinking processes, or at least contemplating whether or not they can think and understand them (metacognition/Declarative Knowledge).

IIF Q2 - I control my own thinking processes.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
27	95	65	23	1



Discussion: When asking students again about controlling their own thinking processes, mirroring the definition of Metacognition given to students, 13% of students Strongly Agreed that they understood their own thinking process, similar to the 12% expressed in the pre-intervention survey (ID Q3). 45% of students Agreed, which was a significant decrease from the 68% in the pre-intervention survey. 31% of students in the post, and 15% of students in the pre-intervention reported being neutral when asked if they control their own thinking processes. 11% of students Disagreed in any way, increased from the 5% of students who Disagreed in any way pre-intervention. This increase in student perception of understanding their thinking processes shows that there has been an increase in students thinking about their thinking processes, or at least contemplating whether or not they can think and understand them (metacognition/Declarative Knowledge).

IIF Comments

Discussion: Few students had comments for this section.

Notable Student Comments:

"I don't know if I control all my thinking processes (PHYS 130B, Article, 2016, Biochemistry Major, Female)."

"I think we should think about the way we think (PHYS 130B, Article, 2018, Biology, Male)."

"I believe my thinking process is largely controled by genes and chemicals in the brain (PSY 100D, No first survey, 2017, Computer Science, Male)."

APPENDIX 8.1 **J. William and Katherine C. Asher Endowment (Psychology)**

DePauw University Mail - A

Rachel

https://mail.google.com/mail/u/0/?ui=2&ik=d5693581f0&view=pt&q=asher%20connie&qs=true&search=query&msg=149e8840f4ab747...

Apps | This. | My Account | Harvard Graduate Sc | The Supreme Court | Alumni Legacy Award | Online video tutorial | Centers, Projects and | Other Bookmarks

DEPAUW UNIVERSITY

Rachel Hanebutt <rachelhanebutt_2015@depauw.edu>

Asher funds - November 2014 - N-14-b - Hanebutt/Stockton

Matt Hertenstein <mhertenstein@depauw.edu> Tue, Nov 25, 2014 at 2:53 PM
To: Rachel Hanebutt <rachelhanebutt_2015@depauw.edu>, Jamie Stockton <JSTOCKTON@depauw.edu>, Connie Lambermont <CLAMBERMONT@depauw.edu>

Dear Rachel,

I'm writing to you on behalf of the Asher Committee members. Competition for Asher funds was keen this round. The committee has partially fully funded your proposal "Metacognitive Regulation in Undergraduate Science Course Instruction." The committee decided to fund the survey copies and instructions in the amount of $229.90. The committee opted not to fund the request for subject compensation; the committee thought that faculty should be approached asking to consider giving extra credit to students (or, just asking faculty to facilitate the project without student compensation which has been done for other similar projects). If you've tried these methods and they are unsuccessful, the committee is open to reviewing a revised application in future funding rounds.

Please work with Connie Lambermont (Psychology dept. secretary) to reconcile your receipts this academic year.

Congratulations and best of luck with your project.

Sincerely,

Matthew Hertenstein – Chair of the Asher Committee

--
****
Matthew Hertenstein
DePauw University
Chair of Psychology
Visit the Touch and Emotion Lab here
www.TheTellBook.com
****

APPENDIX 8.2 **J. William and Dorothy A. Asher Fund (Sociology)**

DEPAUW UNIVERSITY

P.O. Box 37 • Greencastle, Indiana 46135-0037
765-658-4800 • www.depauw.edu

December 15, 2014

Rachel Hanebutt
UB Box

Dear Rachel,

We are delighted to announce that the steering committee of the Asher Fund in the Social Sciences has awarded you up to $100.00 for your project, "Metacognitive Regulation in Undergraduate Science Instruction."

This award is for printing and copying expenses. Please submit your itemized receipts for reimbursement, along with the attached accounting worksheet, to Terry Bruner (377 Julian) within four weeks of completion of your project. (If printing is done in Printing Services at DePauw, please contact Terry for the appropriate account number).

Congratulations on this award!

Carrie Klaus

Carrie Klaus, Dean of Faculty

Jeff Gropp, Chair of the Asher Fund in the Social Sciences