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Student Perceptions About Metacognitive Learning Strategies in Introductory Biology Courses

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Walden University
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Abstract

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M.S.Ed, Long Island University, 2011

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Leadership, Policy, and Change

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Abstract

Active learning and argumentation are metacognitive teaching strategies that have demonstrated an effect on conceptual change in the sciences. Previous research studies have illustrated an association between active learning and argumentation, increased comprehension of content as well as improved academic performance and self-efficacy. However, there is a gap in literature about the perceptions of students on whether these teaching strategies are successful in increasing scientific conceptual understanding and self-efficacy. The first conceptual framework used for this study was Flavell's theoretical and empirical research on metacognition, which provides a process for individuals to regulate their cognitive activity for increasing comprehension. A second framework guiding the study was student efficacy which originates from Bandura's social cognitive theory (SCT) of self-regulation, where self-efficacy described the ability to control and influence events in one's life. The basic qualitative design study with a transcendental approach included two former AP Biology students from a mixed grade level (11th and 12th grade) course who were interviewed to understand their experiences with metacognitive teaching strategies in a college-level course. This study promotes social change by demonstrating how metacognitive teaching strategies and instruction can promote higher-order critical thinking skills which are transferable to other societal domains in a rapidly evolving global society.

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Dedication

I would like to dedicate my dissertation to my mother Catherine Collier, my godmother Glenda Marshall, my goddaughter Shakira Jordan, and my daughters Charette Catherine and Maya Caitlin. I wanted my dissertation journey to inspire my daughters to explore, reflect, create, and to think critically because one person can make a difference in the world. Tempus fugit-Memento vivere! Time Flies-Remember to Live!

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I wish to acknowledge Dr. Celeste Fenton and Dr. Andrew Thomas for their guidance, honesty, and patience throughout my doctoral process. Their mentoring and guidance have been the hearthstone within my dissertation journey for which I am eternally grateful and humble. I would also like to acknowledge Dr. Daniel Vitow for allowing for me to conduct my research at his institution. His support has been unwavering during my dissertation process even during the global pandemic. I wish to acknowledge family and friends that prayed throughout my Walden journey. I wish to acknowledge Yahuah for guidance, strength, and vision during this chapter of my life.

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Chapter 1: Introduction to the Study

Metacognitive teaching strategies, such as active learning and argumentation, are viable methods to increase high school students' conceptual learning in introductory biology. Students' conceptual understanding and performance in introductory biology is increased when active learning and student-centered pedagogy is used (Cleveland et al., 2017; Dehaan, 2005; Dirks-Naylor, 2016; England et al., 2017; Gardner & Belland, 2012, Haak et al. , 2011). Researchers believe active learning can increase self-efficacy in biology and other sciences (Jeong et al., 2019; Wilke, 2003). Scientific argumentation has demonstrated an increase in critical thinking, conceptual change, and learning (Bag & Calik, 2017; Heng et al., 2014; Lazarou et al., 2017).

The purpose of this study was to explore students' experiences with metacognitive teaching strategies and their perceptions about the value of metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology. The social implications of this study are to illustrate how metacognitive teaching strategies (i.e., active learning and argumentation) can promote understanding and conceptual change in the sciences.

Background

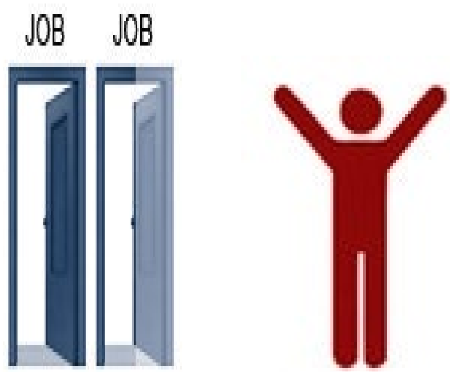
The traditional approach to science instruction neither challenges nor provides students with an opportunity to reflect on the information they have studied (Lord & Baviskar, 2007, p. 41). The problem of 21st-century science education is the inability of students to retain, synthesize, and apply scientific content (College Board, 2014; White, 2014; Lord & Baviskar, 2007). However, science is typically facilitated as full, fact-based content, and assessed by students' ability to recall, summarize, or regurgitate the course content rather than their mastery in analyzing and applying scientific principles and theories (White, 2014; Lord & Baviskar, 2007).

Wood (2009) stated, “the U.S. is doing a relatively poor job at training students in science, technology, engineering, and mathematics (STEM) disciplines” (p. 94). For instance, The National Assessment of Education Progress (NAEP) science test scores for the United States in 2009, demonstrated fourth graders were 34% above proficient with a 4% percent increase in 2015 to 38% above proficient. In contrast, the 2009 NAEP science scores for eighth graders in the United States were 30% above skilled, 32% above proficient in 2011 to 32% above proficient, and 34% above proficient in 2015.

The United States continued to underperform in science even at the twelfth-grade level with no improvement in science exam scores from 2009 to 2015 with a steady 60% at above proficient. The NAEP numerical scores demonstrated consistency with minimal growth for fourth, eighth, and 12th grades from 2009–2015. Consequently, a deficit in science education, instruction, retention, and learning have reduced the number of STEM-skilled graduates as well as fewer job opportunities, as depicted in Figures 1 and 2.

Figure 1

New York State STEM Job Opportunities Illustrates Two STEM Employment Opportunities for Every 1 New Yorker.



http://www.changethequation.com/stem-vital-signs.

Figure 2

New York State Non-STEM Job Opportunities Illustrates 3.4 Non-STEM employment opportunities for every 1 New Yorker.

Note. Adapted from Change the Equation and American Institutes for Research, STEM Vital Signs New York, 2012, *Report of the STEM Vital Signs New York.* Retrieved from http://www.changethequation.com/stem-vital-signs.

If the trend continues the United States will be unable to be internationally competitive in STEM and non-STEM related fields (National Academy of Sciences, National Academy of Engineering [NAE], & Institute of Medicine, 2007; President's Council of Advisors on Science and Technology [PCAST], 2010). While educational policy and standards which focus on increasing content knowledge have been implemented, no such guidelines have been implemented for developing transferable skills such as critical thinking, problem-solving, communication skills, practical collaborative abilities, and/or reasoning skills (Fuad et al., 2017; Mahanal et al., 2016; Mainali, 2012). People learn through experiences and social interactions (Dewey, 1938). Thus, indicating science instruction should provide insightful contexts students can connect to, be motivated, given feedback to learn from failures as well as to improve based on knowledge (metacognition) or develop sound reasoning based on evidence gathered through experimentation or research (argumentation).

Problem Statement

Research has provided compelling evidence that traditional science instruction, used in most secondary school science courses, fails to advance student learning sufficiently (Aji & Khan, 2019; Beck et al., 2014; Flores & Gomez, 2017; Linton et al., 2014; Tanner, 2012). Following the issue of several significant reports such as the American Association for the Advancement of Science (AAAS) report (2011) and the PCAST report (2012), the focus within science higher education reform was to transform learning in undergraduate sciences. The U.S. Department of Education STEM 2026 (2016) report sustains this focus.

Students come to the learning environment from diverse backgrounds and experiences and often with incorrect notions, beliefs, accounts, and understandings of fundamental science concepts, as well as inadequate learning schemes (Tanner, 2012). The National Research Council advised that “more information is needed in engineering, biology, and the geosciences to design assessments that can diagnose students’ difficulties and to design instruction to move them toward more accurate understandings” (Singer et al., 2012, p. 74). Metacognition is associated with improving student learning and academic success (Georghiades, 2000; Dunning et al.; Kruger, 2003). Metacognition is among the instructional strategies recognized as valuable for teaching science (The National Science Academy, 2010; Zohar & Barzilai, 2013). Chauhan and Singh (2014) describe the strategy as “… a systematic cognitive technique to assist students in recognizing, planning, implementing, and monitoring solutions to problems” (p. 22). Metacognition consists of two components: metacognitive knowledge, or what learners know about their ways of thinking, and metacognitive regulation, which involves how learners control their thinking (Flavell, 1993; Veenman et al., 2006).

“Teaching students to use metacognition to understand how they are thinking about biology provides a major step to thinking like a biologist” (Tanner, 2012, p. 114). Active learning and argumentation have been identified as two metacognitive teaching strategies that promote conceptual change in undergraduate sciences (Askell-Williams et al., 2012; Chauhan & Singh, 2014; Darling-Hammond et al., 2012; Gilles et al., 2012; Kristiani et al., 2015; Tanner, 2012; Wood, 2009). However, research about student perceptions on the value of metacognitive learning strategies is limited. The National Research Council asserts that although substantial research has been conducted to unravel students' conceptual understanding in physics and chemistry education, considerably less analysis has been undertaken in the biology discipline (Singer et al., 2012). The Council cites 115 and 120 studies conducted for physics and chemistry, respectively, but only 17 studies were published between 2001 and 2010 to analyze cognition in biology (Singer et al., 2012; Zohar & Barzilai, 2013).

A question arises as to how secondary students perceive and experience learning when their teachers use metacognition as a strategy to promote their learning and conceptual change in science education. In other words, how does it feel for students to think like a scientist? The ability to think like a scientist allows students to recognize the relevance of their academics to the world beyond the classroom and create intrinsic meaning, but how do the students themselves talk about and value this experience? Numerous studies conducted on the impact of metacognition on learning; however, limited research studies have focused on metacognition and the affective aspects of learning (Wajeeh et al., 2018).

I conducted this study to better understand secondary student perceptions about, and experiences with, the integration of metacognition into biology education. Gaining an understanding of students' perceptions about metacognition may help inform the selection of teaching and learning strategies for biology education. Achieving awareness of how students engage with, and respond to, metacognitive instructional practices may help explain the student efficacy for learning introductory biology concepts. I focused on exploring students' experiences with metacognitive teaching strategies and their perceptions about the value of metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology.

Purpose of the Study

The purpose of this study was to explore students' experiences with metacognitive teaching strategies and their perceptions about the value of metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology. My goal was to address the gap in the literature concerning students' perceptions about the value of metacognitive learning strategies and how they impact conceptual changes and learning in biology education. I used a basic qualitative design with a phenomenological approach, which included in-depth interviews to enhance understanding of high school students' opinions, perceptions, and experiences about metacognitive strategies and how these impacted their learning in introductory biology and other post-secondary sciences. My goal for this study was to improve the understanding of high school student perceptions about, and experiences with, metacognitive strategies, such as active learning and argumentation, as valuable methods for conceptual change and learning in introductory biology.

Research Questions

The purpose of the research questions is to direct the data collection procedure. I used the following research questions in this study:

Research Question 1 (RQ1): What are secondary school students' perceptions about metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology?

Research Question 2 (RQ2): What are secondary school students' experiences with metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology?

Conceptual and Theoretical Framework

The study will add to the knowledge base for effective instructional strategies to better understand how high school students think about and respond to metacognition as a learning strategy for conceptual understanding of introductory biology. I used Flavell's (1993) theoretical and empirical research on metacognition as the conceptual framework for this study. The rationale behind metacognition is that it provides a mechanism for persons to regulate their cognitive activity for gaining better comprehension (Papaleontiou-Louca, 2008).

Papaleontiou-Louca (2008) confirmed that two primary components of metacognition, identified initially by Paris and Winograd (2006), are self-appraisal and self-management, while Veenman et al. (2006) discussed the concepts in terms of metacognitive knowledge and metacognitive regulation. The two specific types of metacognition that I addressed in this study were active learning and argumentation. Active learning incorporates several instructional strategies, including problem-solving, collaboration and discussion, models, and technology-enhanced activities (Gardner & Belland, 2012). Scientific argumentation is the attempt to validate or refute a claim based on reasons in a manner that reflects the values of the scientific community (Norris et al., 2007).

A second framework that I used to guide the study was self-efficacy. Self-efficacy refers to the individual's aptitude to generate preferred outcomes. Self-efficacy beliefs refer to an individual's confidence about practices that lead to self-efficacy in educational goals, including possessing the competence to use those practices. Student self-efficacy refers to the magnitude of confidence students have that they can shape their learning outcomes. Baldwin et al. (1999) emphasized the significance of students' confidence in understanding biology as well as increased academic performance.

Bandura's social cognitive theory (SCT) of self-regulation and self-efficacy (1991, 1993, 1994), describes the ability to control and influence events in one's life is utilized within this study. I used SCT for this study because it provided a lens for viewing learning and conceptual change as a social, interacting, and knowledge-building experience. Student self-efficacy was relevant to this research as it refers to one's beliefs rather than observable or measured behavior.

Definitions of Terms

Active learning: Describes a metacognitive teaching strategy in which students engage in doing things and thinking about what they are doing in the classroom. Active learning within this study included technologically enhanced activities, 3D models based on unit concepts, case studies based on content knowledge, problem-solving, role play, collaboration, and discussion.

Argumentation: An attempt to validate or refute a claim based on reasons in a manner that reflects the values of the scientific community (Norris et al., 2007).

Metacognition: Flavell (1979) described metacognition as follows:

Metacognitive knowledge is divided into three sections: person, task, and strategy. Knowledge of person involves common knowledge about how the individual understands and processes information, as well as personal knowledge of their own learning processes. Knowledge of task includes understanding about the nature of task as well as the type of processing demands that it will place on the individuals. Knowledge of strategy combines cognitive and metacognitive strategies as well as the individual knowing why she/he are learning the assigned task (p. 907).

Metacognition experiences, on the other hand, is a term that refers to any conscious cognitive or affective experiences that accompany and pertain to any intellectual enterprise (p.908).

Metacognitive (teaching) strategy: A cognitive technique used in a systematic way to help students recognize, plan, implement, and monitor their approach to solving problems (Chauhan & Singh, 2014, p.21).

Self-efficacy: Perceived self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. Self-efficacy beliefs determine how people feel, think, motivate themselves and behave. Such beliefs produce these diverse effects through four major processes. They include cognitive, motivational, affective and selection processes (Bandura, 1994, p. 2).

Assumptions

In this study, I assumed:

1. The students would have had active learning and argumentation in previous science courses.
2. The students believed their present modes of instruction in sciences promote conceptual change and understanding in science courses.
3. The students worked cooperatively with each other during all activities.
4. The students were honest throughout their interview process.

Scope of the Study

I conducted this study in three mixed grade level (11th &12th) AP Biology courses in Long Island, New York. The private high school's population is 440 students with 51 instructional faculty members. The following criteria guided the student participant sample recruitment: (a) a cumulative average of 90% in the sciences (i.e., general biology and general chemistry), (b) a cumulative average of 90% in mathematics, (c) a prerequisite of algebra or pre-calculus, and (d) a student must be either in the 11th and/or 12th grade. The total enrollment for the courses would be 50 students who presented an appropriate sample size.

The rationale behind the sample size was two-fold: (a) the study only explored students registered for AP Biology, and (b) ninth and 10th graders are not allowed to enroll in the course at the high school where the study was taking place. The instructor created the curriculum and syllabus with College Board approval per federal and state education laws which fostered inquiry-based as well as an argument-driven inquiry for learning college-level introductory biology. The study's findings are applicable outside the testing environment with training and embedded professional development.

Limitations

This study had several limitations. The first potential limitation was that this study was limited to a specific time frame such as a participant is in either the 11th and/or 12th grade during the school year 2019–2020. The next possible limitation was researcher bias based on transcendental phenomenological approach as a part of research methodology. However, I engaged in epoché which is constant awareness of bias regarding the phenomenon and the removal of those biases during all stages of research. Additionally, I used reflective journaling and identified my biases. The third possible study limitation was location because the study site is a private religious high school, which may affect generalizability. Homogeneity would be a fourth limitation that could hamper generalizability. The fifth limitation of study could be the access to financial support and resources that may be inaccessible by other some urban and rural schools.

Significance of the Study

STEM employment over the last decade has grown over 24% compared to 4% for non-STEM jobs, and is expected to experience continued growth through 2026 (Noonan, 2017). There has been a greater emphasis on STEM education, and the need for students to be able to think critically, conduct research, evaluate data, and solve problems especially using STEM knowledge acquired through studies in STEM subjects (U.S. Department of Education, n.d., a). According to the U.S. STEM 2026 Vision report, the identification of learning activities, educational experiences, teaching practices, and innovative measures of learning are critical components of moving STEM education forward to meet the needs of our nation and students (U.S. Department of Education, 2016). This research will help to fill a gap in understanding secondary students' perceptions about metacognition and the value it may have for learning introductory biology concepts. Although not the focus of this study, a potential benefit of this research was to inform professional development for teachers and support theory to practice for teaching biology. Understanding which strategies high school students valued may influence which strategies and best practices teachers choose to implement. Teachers may desire to participate in professional development focused on metacognition if they deem metacognition useful for helping students learn biology concepts. If teachers believe that metacognition can help students learn biology concepts, they may be more likely to model and incorporate these techniques into their teaching practice.

Summary

The study's purpose and intent were relevant to and aligned with Project 2061, the long-term research initiative postulated that produced Science for All Americans. Science for All Americans is a science education toolkit, which outlines Project 2061 goals for improving science learning goals, perfecting assessment, and enhancing teachers' professional development (AAAS, 2011). However, the overarching project objective is to develop scientific literacy as well as more effective ways of teaching. The current science education research community is striving to effect conceptual change, comprehension, and an understanding of the nature of science. In conjunction, the Project has postulated that today's society requires teaching strategies that promote critical thinking as well as soft skills. Through greater awareness of high school students' perceptions of metacognition and metacognitive experiences, the study results will provide greater insight into the learning strategies that resonate and inspire confidence in learning introductory biology with high school students.

Chapter 2 includes a detailed review of the literature examining the concepts of metacognition and metacognitive teaching strategies. In this section, I identified and discussed metacognition, metacognitive teaching strategies, conceptual change, and students' experiences learning with metacognitive strategies, and students' perceptions about metacognition.

Chapter 3 includes in detail the research design for this study and the rationale for the method. Upon conclusion of the study, Chapter 4 includes an explanation in detail the research findings from the data analysis, and Chapter 5 includes a conclusion to the study and recommendations for future research.

Chapter 2: Literature Review

Introduction

The 21st-century student should be able to collaborate effectively with their contemporaries in building a just society with the ability to sustain its pecuniary vivacity and safeguard defense in an ever-changing world. A quality education for all American citizens is fundamental for attaining these goals. As one of the natural sciences, biology influences the invention and creation of new medicines. It is vital in the understanding of human reproduction by explaining discoveries to solving fertility and fecundity issues. On the other hand, biology investigates environmental issues and produces data which improves the quality of life. In this study, I explored students' experiences with metacognitive teaching strategies and their perceptions about the value of metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology.

Literature Search Strategy

The literature review research originated from peer-reviewed journals, articles, books, and primary sources. The study explored metacognition and metacognitive teaching strategies in instruction as to whether they affected conceptual change. Similarly, the study examined the formation of experiences and perceptions of learning through metacognition. For instance, research studies illustrate teacher perceptions about metacognition and metacognitive teaching strategies' effects on learning. Subsequently, the study postulated processes on how to integrate metacognitive teaching strategies. Moreover, recommended processes and procedures for data collection pertinent to the study design. I began the literature search with books and journal articles used in the dissertation program.

My investigation expanded to other sources recommended by experts in the field of method and theory to conduct this research study. In searching for materials to support my research, I used keywords from the title of the study to retrieve articles relevant to metacognition and metacognitive teaching strategies, metacognition and conceptual change, integration of metacognitive teaching strategies, students' conceptual change as the result of metacognition, and student perceptions and experiences in learning with metacognition. I used Google Scholar, ERIC, and Walden online library as my primary resources. Electronic folders specific for each concept were created on my computer and used to organize the literature sources.

Theoretical Foundations

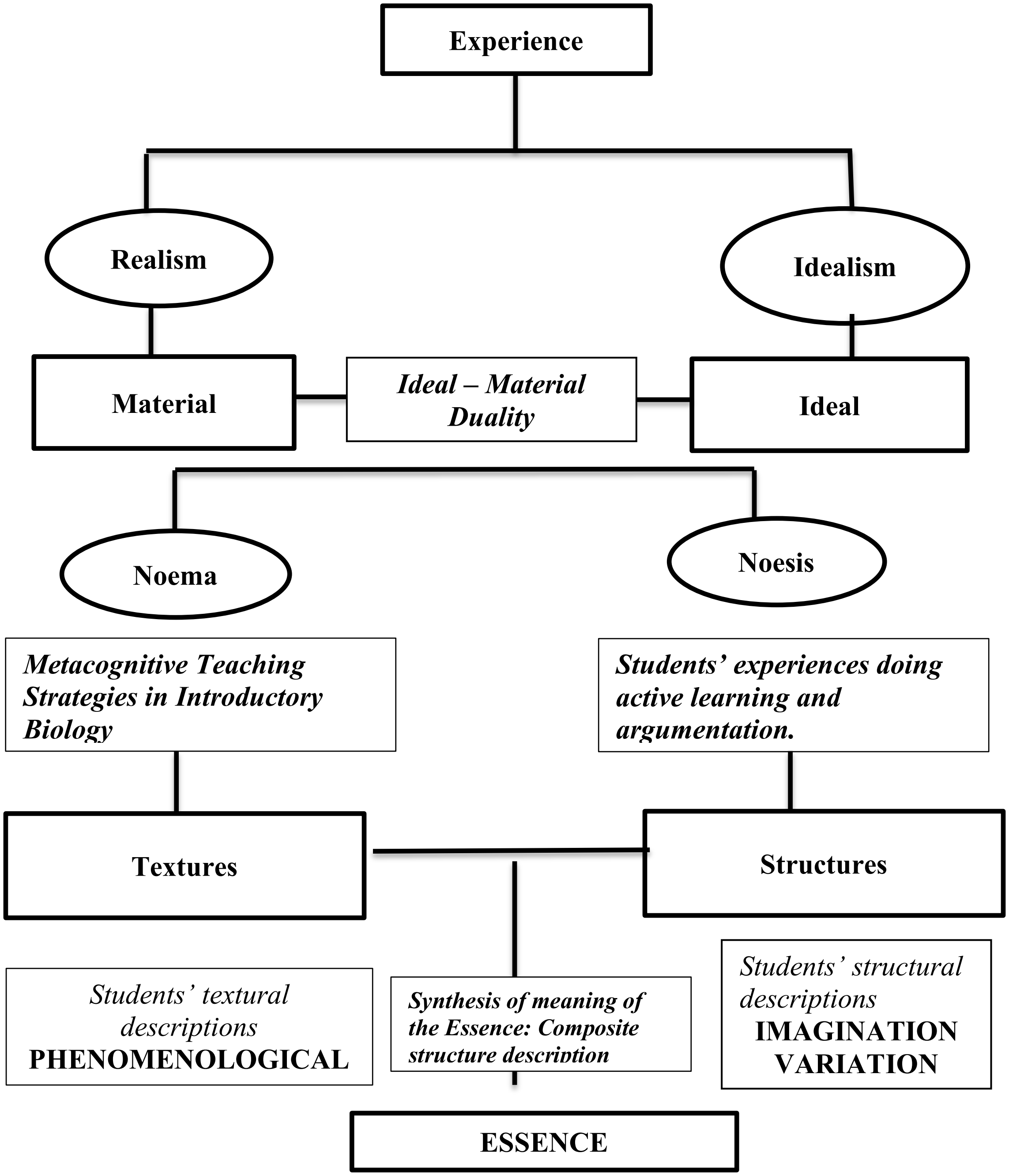
The foundation of metacognition was developed in Flavell's (1993) theoretical and empirical research on metacognition. Metacognition provides a means for individuals to police and control their cognitive activity to achieve better comprehension (Papaleontiou-Louca, 2008). Two primary components of metacognition initially identified by Paris and Winograd (2006) and confirmed by Papaleontiou-Louca (2008), are self-appraisal and self-management. Although Veenman et al. (2006) discussed the concepts of metacognitive knowledge and metacognitive regulation, in this study, the types of metacognition addressed are active learning and argumentation. Several instructional strategies such as problem-solving, collaboration and discussion, models, and technology-enhanced activities are primary active learning components (Gardner & Belland, 2012). The attempt to validate or refute a claim based on reasons in a manner that reflects the values of the scientific community is the primary element of scientific argumentation (Norris et al., 2007).

The second theoretical body of work that grounded this study was student self-efficacy. Student self-efficacy denotes the magnitude of confidence students possess to influence their learning. Baldwin et al. (1999) believed that efficacy, or students' confidence, was crucial in understanding and learning biology. Bandura's (1991, 1993, 1994) SCT of self-regulation and self-efficacy contributed significantly to work on self-efficacy. The SCT of self-regulation and self-efficacy described the ability of individuals to control and influence events in their life. To investigate learning and conceptual change in a social context, I used this theory as the foundation for this study. These theories promote the ability to explore beliefs, feelings, and experiences regarding metacognition and conceptual change.

The study used transcendental phenomenology as a theoretical approach to explored high school students' experiences with metacognitive teaching strategies in introductory biology. The theoretical approach of transcendental phenomenology is appropriate to individually examine the lived experiences of the phenomenon from the perceptions of those who experience them (Giorgi, 1985; Moustakas, 1994). Subsequently, the researcher used phenomenology as an approach to facilitate understanding "the hidden meaning and essence of experience together with how the participant makes sense of these experiences" (Grbich, 2013, p. 92). On the other hand, "its emphasis on looking closely at lived experience in specific settings, rather than abstract theorizing about human nature" to avoid researcher bias or "when expert professionals impose their theories on the experiences of the people they are supposed to be serving" (King & Horrocks, 2010, pp. 181-182). I used a transcendental phenomenological approach to study the effectiveness of metacognitive teaching strategies through students' perceptions in a bounded context. Figure 3 illustrates the phenomenology concept of experience for this study.

Figure 3

The phenomenological Concept of Experience



Note: Adapted from "Educational computer uses leisure contexts: A phenomenological study of adolescents' experiences at Internet cafes" by S. Cilesiz, 2009, *American*

Educational Research Journal, 46(1), p. 234. The rectangles equal elements and circles equal underlying concepts of the study.

I used a transcendental phenomenological approach to study the effectiveness of metacognitive teaching strategies through student perception in a bounded context. Thus, the meaning is "a phenomenon occurring in a bounded context" (Miles & Huberman, 1994, p. 25) which is applicable for a case study research design; however, I am also interested in how the students interpret the metacognitive teaching strategies' effectiveness as well as do the strategies expand conceptual change and learning in biology.

In contrast, a quantitative research design was inappropriate because the research questions are not testing for a causal relationship but rather, it is an exploration of the descriptive experiences. Unlike quantitative research, the researcher becomes part of the research process through data collection and analysis in qualitative research. Thus, as a result, the researcher can affect data collection or analysis; hence, this was an ongoing critique of this research design. I used the phenomenological theoretical framework to depict the potential for examining student experiences with metacognitive teaching strategies.

Metacognition

John Flavell proposed "metacognition" as a learner's knowledge of their cognition, defining it as "knowledge and cognition about cognitive phenomena' (p. 906). Accordingly, within the literature review, individuals thinking about their thought processes or cognitions about cognition n referred to as metacognition. Metacognition refers to knowledge, awareness, and control of learning processes (Brown, 1987; Garner & Alexander, 1989; Thomas & McRobbie, 2001).

Self-appraisal and self-management during the 1980s were two additional aspects of metacognition (Cross & Paris, 1988; Paris & Jacobs, 1984; Paris & Winogard, 1990). Self-appraisal is a student's ability to understand their learning capabilities and strategies through reflection during their thinking process, while student self-management delves into the aspect of students' mental process during problem-solving (Paris & Winogard, 1990, p. 8).

Based on these premises, metacognition illustrated a promising approach to learning and conceptual change specifically since post-Sputnik education reform sought to develop critical, higher-order thinkers, as well as scientifically literate citizens for the future of America. For example, the education research community proposed that future schools should implement metacognition within their existing curricula (Flavell, 1987), while other researchers postulated metacognition as a prerequisite of pre-service teacher education (Borkowski & Muthukrishna, 1992; Paris et al., 1994; Paris & Winogard, 1990).

Metacognition in education reform is still in effect today; however, the movement's origins predate the 1970s. The origin of metacognition trace back to ancient civilization (Plato, 1941, 385, 348, B.C.E.; Aristotle, 1984) and the early 19th/20th century (Dewey,1910; Thorndike, 1914; Locke, 1924; Piaget, 1976; Campione, 1987) as well as metacognition postulated as reflective practices of the mind. Although metacognition has been studied for 49 years and led to a vast amount of literature, both theoretic and experimental, there has not been a consensus on a theoretical framework or proposed definition of the superordinate term metacognition (Brown, 1987; Campione, 1987; Moore, 1982; Paris & Jacobs, 1984; Winograd, 1990). The term metacognition sometimes referred to as "reflective thinking," has been postulated as a valid means of critical higher-order thinking (i.e., cognition) to increase learning and encourage life-long learning (von der Linden et al., 2015).

Despite the uncertainty of the term *conceptualization* (Flavell, 1987), metacognition is representative of cognition, which operates at a meta-level and is associated with the object-world (i.e., cognition) through the monitoring and control activities. Flavell (1978) posited metacognition as "knowledge that takes as its object or regulates any aspect of any cognitive endeavor" (p. 8). Clarifying his earlier research, Flavell postulated that metacognition involved cognitive monitoring/regulation. Flavell (1979) theorized that during cognitive tasks, various interactions occur in four classes of phenomena: metacognitive knowledge, metacognitive experiences, goals/tasks, and actions/strategies (p. 906).

The two indicators of the monitoring function are metacognitive knowledge and metacognitive experiences (Flavell, 1979). On the other hand, Brown (1978) distinguishes between knowledge about cognition and regulation of cognition, which leads to metacognitive skills or use of strategies, and in contrast are indicators of the control function (Brown, 1987; Efklides, 2006). Flavell (1979) further delineated metacognition as the three sections of metacognitive knowledge: person, task, and strategy (p. 907). Knowledge of person involves common knowledge about how the individual understands and processes information and personal knowledge of their learning processes. Knowledge of tasks includes understanding the nature of the assignment and the modes of processing exigencies that will affect the individuals. The knowledge of strategy component intermixes cognitive and metacognitive strategies and the individual discerning why they are learning the assigned task. The three areas of metacognition are in Table 1.

Table 1

The three areas of metacognition and their indices as a role of monitoring and control

Monitoring		Control
Metacognitive knowledge	Metacognitive experiences	Metacognitive skills
Ideas beliefs theories of	Feelings Feelings of difficulty Feelings of knowing Feeling pf confidence Feeling of satisfaction	Conscious, deliberate activities and use of strategies for effort allocation
Person/self	Judgments/estimates	Time allocation
Task	Judgment of learning	Orientation/monitoring of task requirement/demands
Strategies	Source memory information	Planning
Goals	Estimate of time	Check and regulation of cognitive processing
Cognitive functions (e.g., memory, attention, etc.)	Estimate of effort	Evaluation of the processing time
Validity of knowledge	Task specific knowledge	
Theory of mind	Procedures employed	

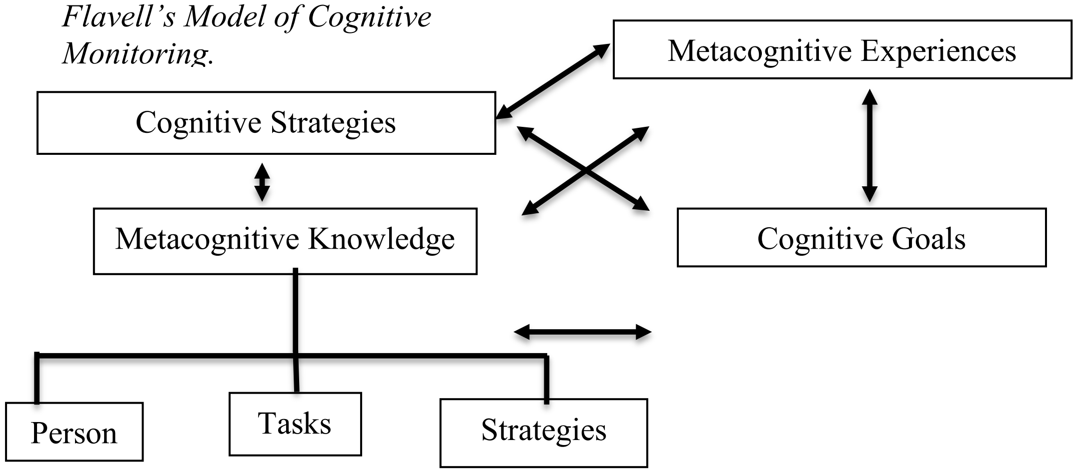
From "Metacognition and affect: What can metacognitive experiences tell us about the learning process?" by A. Efklides,2006, *Educational Research Review, 1*, p. 4.

Metacognition experiences refer to any conscious cognitive or affective experiences accompanying and about any intellectual enterprise (p.908). For example, a student with an upcoming biology exam on Mendelian genetics may feel she/he feels might fail the exam. These metacognitive experiences can happen before, during, and/or after an individual begins a task or assignment. Metacognitive experiences, according to Flavell, are correlated to an individual's assessment of the current learning experience. Researchers suggest that metacognitive knowledge through metacognitive experiences occurs within the working memory (Flavell, 1979; Lories et al., 1998). To illustrate this phenomenon, a student is having difficulty with the chemical interactions during protein folding at the tertiary level. She/he recalls a previous example from a lecture that she/he understood and solved; hence this recollection will allow for completion of the problem.

Metacognitive experiences can modify an individual's cognitive goals, tasks, metacognitive knowledge, and cognitive strategies. These experiences may lead to refining goals, reflection on goals, and even eradication of old goals. Similarly, metacognitive experiences can increase, decrease, and/or refine base metacognitive knowledge. At the same time, metacognitive knowledge will modify without any metacognitive experiences. For instance, a student feels that she/he is unprepared for the midterm exam (metacognitive experience), then she/he will restudy the areas (cognitive strategy) to reach an understanding of the subject (cognitive goal). Figure 4 highlighted Flavell's model of cognition.

Figure 4

Flavell's Model of Cognitive Monitoring.



Note. From "Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry" by J. H. Flavell, 1993, *American Psychologist, 34,* p. 40.

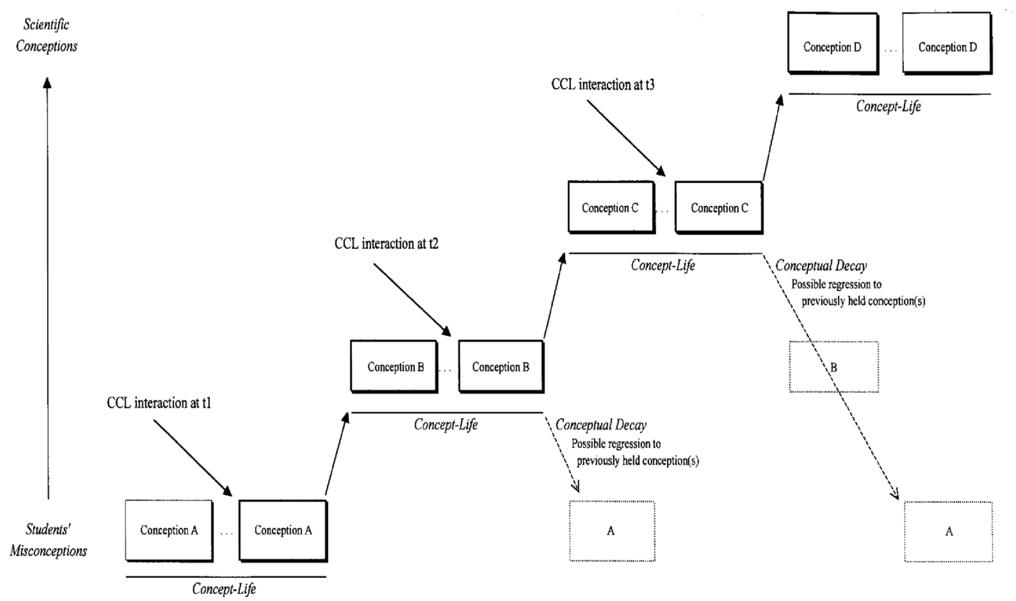
Metacognition and Conceptual Change

Science educators at all levels are experiencing similar learning and retention issues, whether in public or private school settings and at the post-secondary and graduate levels. Many students cannot utilize school-learned science in different contexts, forgetting what they have learned in a short time after initial instruction (Georghiades, 2000, p. 120). Metacognition and its possible effects on conceptual change, learning, and instruction have been an area of interest in science education research for over 25 years (Chauhan & Singh, 2014; Gunstone & Horthfield, 1994; Georghiades, 2000; Gunstone & Mitchell, 2005; Pintrich, 2002; Shaw et al., 2006; Tanner, 2012; White et al., 2011; Veenman, 2012).

Researchers have posited that metacognition and its components can promote conceptual change in science education, lasting effects for life-long learning across fields (von der Linden et al., 2015). The process of conceptual change in science education is the capability to convey recently learned scientific conceptions to new situations, the permanence of scientific conceptions strong enough to eradicate the student's scientific misconceptions depicted in Figure 5.

Figure 5

The Process of Conceptual Change



Note. "From the general to be situated: Three decades of metacognition" by P. Georghiades, 2004, *International Journal of Science Education, 26*(3), p. 125.

Conceptual change and metacognition occur through identifying misconceptions then assessing those misconceptions hence leading a student to decide whether to reform and/or evaluate all metacognitive processes. These processes are metacognitive knowledge, metacognitive experiences, monitoring, and self-control. Metacognition and conceptual change are required for comprehension in the sciences and becoming a critical thinker and problem solver for our current technological society. Further, in 2012, future New York State STEM and non-STEM employers stated they required a workforce that can be innovative and acclimate to a variety of cognitive tasks promptly.

Metacognition and conceptual change research demonstrate the beneficial effects in science education and suggest these strategies can promote comprehension and understanding in Biology and other sciences. While metacognition postulates domain-specific knowledge, in retrospect, the ‘domain’ spans all other cognitive domains (Flavell, 1985; Louca, 2003). Previous research led current science educators to develop or integrate metacognitive instruction and teaching strategies into existing curricula. The research considered active learners aware of their strengths and weaknesses and developed ways to fix the latter (Lin, 2001, p. 23). Typically, students do not automatically engage in metacognitive thinking without explicitly stated directions for the assignment (Lin & Lehman, 1999). Brown (1992) articulated that the design of learning environments is critical to developing cognitively and socially competent metacognitive learners. Metacognitive learners develop through the curricula design based on metacognitive teaching strategies to foster cognition and metacognition (Brown, 1992).

Metacognitive Teaching Strategies

The metacognitive teaching strategy is defined as “a systematic cognitive technique to assist students in recognizing, planning, implementing and monitoring solutions to problems” (Chauhan & Singh, 2014, p.21). Research studies reveal that metacognitive teaching strategies (i.e., active learning and argumentation) that teach the student to be an efficient learner range from staggering implementation to no usage in the classroom (Ellis, Bond, & Denton, 2012; Kistner et al., 2010). Research studies illustrated limited curricula integration of active learning and/or collaboration amongst educators (Haidar & Al Naqabi, 2008; Kistner et al., & Kliene, 2010). Similarly, even after international and national organizations emphasized argument through the epistemic nature of science (National Research Council [NRC], 2007, and Organization for Economic Co-operation and Development [OECD], 2003), argumentation is unevenly implemented or not an established practice (NRC, 2007 & Osborne & Dillon, 2007). In the context of this study, exploring the experiences and perceptions of high school students will illustrate the effectiveness of active learning and argumentation for promoting conceptual change and learning in introductory biology.

Active Learning

For over 28 years, science educational research has demonstrated active learning as a metacognitive teaching method that increases conceptual change, learning, and understanding in the K-12 as well as post-secondary sciences (Armbruster et al., 2009; Corkin, Horn, & Pattison, 2017; Jensen et al., 2014; Kim et al., 2012; Linton et al., 2014; Sletten, 2017; Wilke, 2003). Active learning has a theoretical foundation based on constructivism. *Constructivism* is a learning theory that postulates that constructed knowledge links new ideas and experiences to prior knowledge and experiences to develop new or increased understanding. Constructivist learning involves reasoning, critical thinking, understanding, and the use of self-knowledge, self-regulation, and mindful reflection.

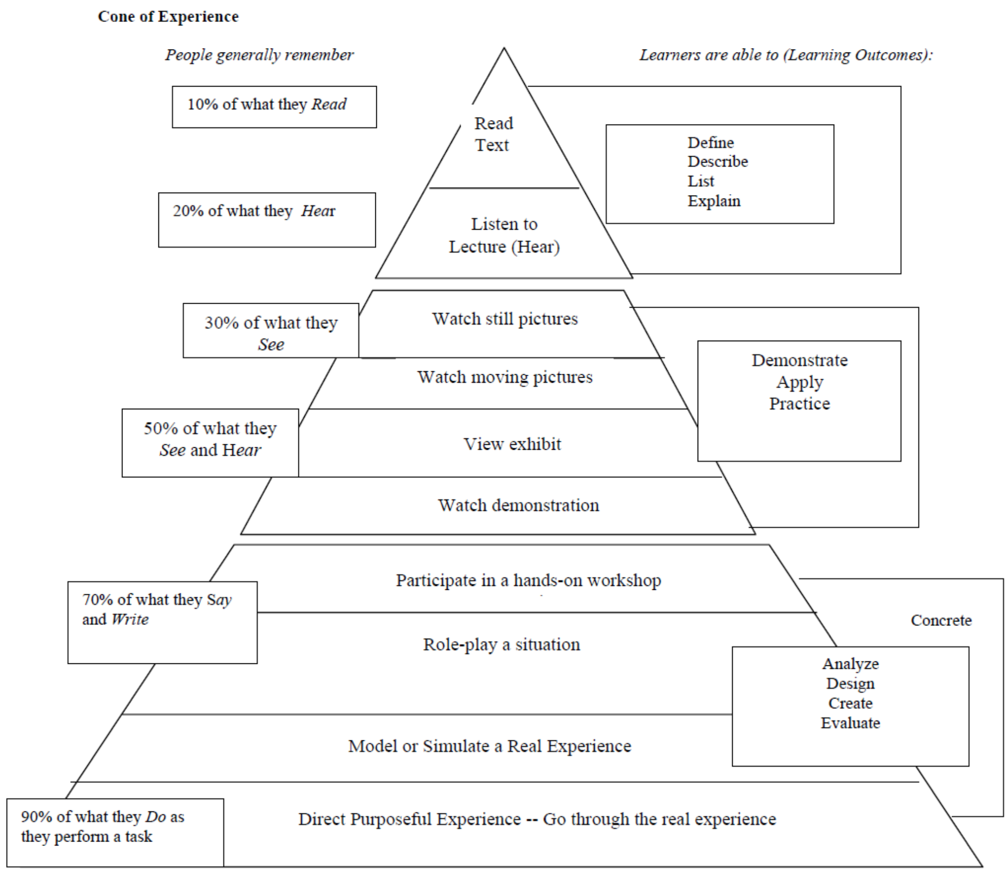
Active learning promotes comprehension rather than memorizing facts, which students can apply to various contexts and problems. It is this insight and problem-solving methodology that businesses and universities pursue. Also, active learning cultivates students' learning and independence, thereby giving them hegemony over their learning and possibly an aptitude to be lifelong learners (Armbruster et al., 2009; Bonwell & Eison, 1991; Freeman et al., 2014; Freeman et al., 2011; Gopalan, 2016;

Nelson & Crow, 2014; Rutledge et al., 2015). The learning goals and classroom conditions demonstrate metacognition in science education and learning. Unlike metacognition, active learning standard definition stated higher-order thinking activities required students to construct knowledge and understanding to learn. Although active learning assignments can vary in difficulty, higher-order thinking is still required.

Furthermore, students' metacognition is implicit within the instructions within these activities, but there is a linkage between activity and learning. The tenets of constructivism promote metacognition, which was depicted as active learning, as an alternative to traditional instruction as early as the 1960s. Dale (1969) postulated that "learners retain more information by what they 'do' as opposed to what is 'heard' 'read,' or "observed'" (p. 108). For instance, Dale's Cone of Experience illustrated how students process information in Figure 6.

Figure 6

Visual Methods in Teaching



Note. From Audio-Visual Methods in Teaching, by E. Dale, 3rd., Holt, Rhinehart & Winston, NY, 1969, p.108.

The challenges to implementing active learning include educator inexperience (Bonwell & Eison, 1991; Creed, 1986), limited academic progress despite intervention (Sadeghi, Sedaghat, & Ahmadi, 2014, educator resistance (Armbruster et al., 2099, Evan & Leppmann, 1967; Miller & Metz, 2014), and student resistance (Finelli et al., 2018). Educators sometimes do not apply models and theories correctly for active learning, such as Gardner's multiple intelligences, which describes how students process information, is adopted as an active learning strategy. Educators' misconceptions or lack of understanding about how to implement active learning led some educators to expect a student to learn independently or in groups, with the student acting solely as a facilitator.

Nevertheless, active learning and its theoretical framework of constructivism promote metacognitive learning and comprehension. Active learning can be combined with other metacognitive teaching strategies to provide scaffolding in learning science content. Active learning includes discussion then argumentation to clarify misconceptions through claims, reasoning, and justifications from research (i.e., case study, socio-ethical issue, or unit summative assessment).

Argumentation

The empirical research has demonstrated the positive effects of argumentation for over 39 years as well as its effect on learning content knowledge (Zohar & Nemet, 2002) and conceptual change (Faize et al., 2018; Kaya et al., 2012; Nussbaum & Sinatra, 2003, Sampson & Clark, 2009; von Aufschnaiter et al., 2008). Researchers, national and global reports have identified the need for the inclusion of argumentation practices in science education (American Association for the Advancement of Science [AAAS], 1993; Acar & Patton, 2012; National Research Council [NRC], 1996, 2012, Sampson & Clark, 2009; Tsai, 2013). Argumentation promotes scientific literacy (Braaten & Windschitl, 2011; Cavagnetto, 2010, Driver et al., 2000; Sampson & Clark, 2011) and scientific practice, supported by science concepts (Driver et al., 2000; Sadler, 2004), science processes, metacognitive processes (Mason & Santi, 1994), and deductive reasoning skills (McNeill & Pimentel, 2010). Language in the classroom develops through metacognition, social interaction, and deductive reasoning (Ford, 2008; Norris & Phillips, 2003; Vygotsky, 1978).

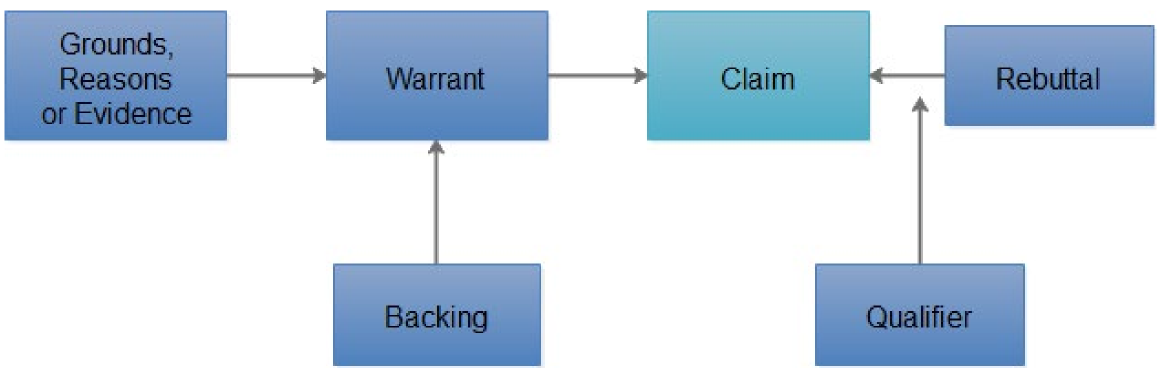
Language is social interaction; hence, argumentation allows students to construct and communicate knowledge (Brown, 1990; Duschl, 2008). Similarly, argumentation is depicted as the language of science, as it allows the student to understand scientific processes, increase communication skills, analyze scientific literature critically, and higher-order thinking (Eskin & Berkirglu, 2008) increased deductive/inductive reasoning skills. Despite the benefits of argumentation for increased conceptual change and critical thinking skills, the strategy has either not been utilized or improperly implemented within the classroom. Teacher education programs provide incomplete pre-service teacher education in argumentation (Boran & Bag, 2016; Driver et al., 2000) and limited integration into existing curricula for secondary level sciences (Heng & Johari, 2013).

However, the inconsistency in its implementation and practice could stem from "argument," "argumentation," and "explanation" having interrelated as well as multiple meanings in science education (Berland & McNeill, 2011;). For example, explanations elucidate or describe a natural phenomenon, arguments specify and substantiate an explanation, and argumentation is the process of constructing explanations, creating arguments, assessing the practices, perspectives, and outcomes of analysis (i.e., explanations or arguments) (Sampson & Blanchard, 2012, p.456).

Argumentation implementation from kindergarten through post-secondary level sciences have utilized Toulmin's model of argumentation pattern [TAP] (1958) or a modified version of his model (Mason & Santi, 1994; Osborne & et al., 2004; Sampson & Clark, 2008). Toulmin posited a cogent argument with six components: claim, data, warrants, qualifiers, backing, and rebuttals. A *claim* is an assertion stated to be concurred with by the general audience. Grounds, or data, are the empirical evidence used to validate the claim. The warrants are general and logical statements that serve as a link between data and claim. The strength of an argument by making a statement is a qualifier, and it includes statements about the validity of the argument. The backing supports the warrants; however, it does not prove the argument is accurate. The rebuttal is a counterargument which contrary to the initial claims of the argument. Figure 7 illustrated the six components of the Toulmin Model of Argumentation.

Figure 7

The Six Components of Toulmin Model of Argumentation

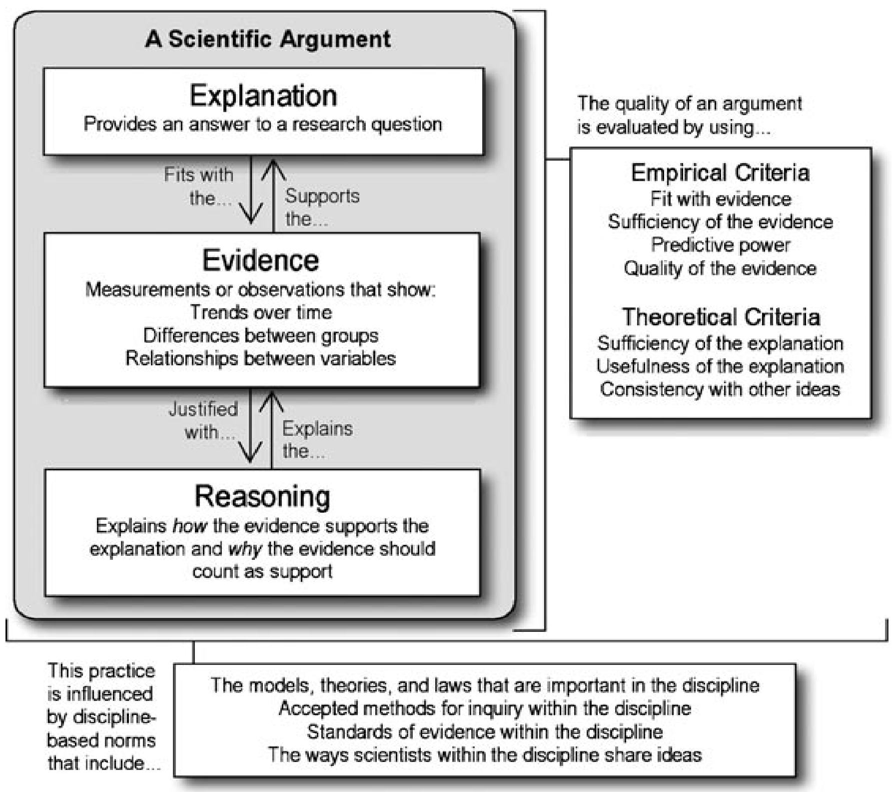


Note. From https://www.edrawsoft.com/draw-toulmin-model.php, p. 1.

Recent research studies have demonstrated that Toulmin's TAP model is ineffective regarding the quality of the information at the grounds level (Osborne et al., 2004). Similarly, other researchers articulated that Toulmin's model cannot assess whether an argument is valid or not (Sampson & Clark, 2008) and apply to mostly socio-scientific content domains (Driver et al., 2000; Zohar & Nemet, 2002; Sampson & Clark, 2011). These slight flaws demonstrated within the TAP model allowed researchers to adopt a model that promoted high-quality argument development in science education. For this study, an attempt to validate or refute a claim based on reasons that reflect the values of the scientific community defines argumentation (Norris et al., 2007). This study will utilize the adapted Toulmin model used by other researchers (Kuhn & Reiser, 2005; Liotte et al., 2004; McNeill & Krajcik, 2007; Osborne et al., 2004. Figure 8 illustrates the modified argumentation model used for this study.

Figure 8

The Argumentation Framework Used in This Study



Note. From “Science teachers and scientific argumentation: Trends and views and practice”, *Journal of Research in Science Teaching, 49*(9), p. 1124.

The adapted model has three components which are an explanation (claim), evidence (data), and reasoning (warrants and backings). Specifically, this model requires students to construct an answer to a research question postulated for laboratory or research. For example, students can explain a problem, control, and experiment on animal behavior, or explore the relationship between the cell membrane and water potential. The evidence component requires data, observations, or peer-reviewed literature, to validate the explanation, such as the quantitative and qualitative data gathered in the laboratory or field study. As a final point, the reasoning component established the argument must rationalize why the data (evidence) supported the student's initial claim, including a justification for why the evidence is valid.

Scientific argumentation is an epistemological pursuit of the scientific community (Duschl, 2008) and is an attribute that separates science from other areas of expertise. Next Generation Science Standards (NGSS) and National Research Council Framework for K-12 Science Education (NRC) articulate that scientific argumentation should function as a link between the scientific community and the science classroom, suggesting that engaging in discourse will attribute to critical thinking skills, problem-solving methodology, innovation, and reflective practices (NGSS, 2012; NRC, 2012). Science literacy has been an explicit goal post-Sputnik to develop a society of critical and reflective thinkers in science education reform (AAAS, 1993; NRC, 1996). Similarly, businesses and universities seek these types of innovative individuals to stay on the competitive edge within an ever-changing technologically advanced global community.

Chapter 3: Research Method

The purpose of this study was to explore students' experiences with metacognitive teaching strategies and their perceptions about the value of metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology. I used a basic qualitative design with a phenomenological approach to interpretation, which included semi structured in-depth interviews to enhance understanding of high school students' opinions, perceptions, and experiences about metacognitive strategies and how they can impact their introductory biology post-secondary sciences. This study improved the understanding of high school student perceptions about metacognitive strategies, such as active learning and argumentation, as sustainable methods for conceptual change and learning introductory biology.

In Chapter 3, I outline a basic qualitative research design with a phenomenological approach. Qualitative questions evolved to understand students' perceptions of active learning and argumentation and whether the strategies affected their ability to learn introductory biology. I will discuss my role as a high school researcher and identify protocols utilized to obtain participants. The methodology section includes participant selection logic, instrumentation of researcher-developed interview questions, participants recruitment, participation and data collection, and a data analysis plan. Lastly, I examine issues of validity and trustworthiness of the qualitative data and the ethical issues for researching within an educational setting.

Research Design and Rationale

In this study, I used the following research questions for data collection.

RQ1: What are secondary school students' perceptions about metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology?

RQ2: What are secondary school students' experiences with metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology?

The concepts addressed in this study are active learning and argumentation. Active learning incorporates several instructional strategies, including problem-solving, collaboration and discussion, models, and technology-enhanced activities (Gardner & Belland, 2012). Scientific argumentation is the attempt to validate or refute a claim based on reasons in a manner that reflects the values of the scientific community (Norris et al., 2007). Understanding which teaching strategies students value may influence which strategies and best practices educators and other stakeholders choose to implement in science education. Subsequently, it is essential that students' perspectives directly involved in the learning process of biology be the focus of the data collection.

According to Merriam (1998), the primary instrument of data collection and analysis in the qualitative study should be the human beings closest to the researched phenomena. Willig (2013) asserted that "different people can, and do, perceive and experience (what appears to be) the same environment in radically different ways" (p. 252). A basic qualitative design with a transcendental phenomenological approach applied in this study was to understand student perceptions, both emotionally and intellectually, through their experiences with metacognitive teaching strategies. The methodology of a basic qualitative design with a transcendental phenomenological approach involves suspending presuppositions, assumptions, and judgments; describing the phenomenon in its entirety; and integrating the data to attain a complete understanding of the essence of the phenomena (Willig, 2013) as well as the process will make use of "thick, rich" extended interviews (Lincoln & Guba, 1985).

Transcendental phenomenology research is a methodical approach to reveal and explain the structures of a lived experience to attain a more profound understanding of the quality or meaning of experiences of phenomenon (Giorgi, 1985; Husserl, 1970a, Moustakas, 1994; van Maren, 1990). In contrast, other qualitative approaches do not have a theoretical framework and methodology explicitly created to investigate lived experiences of phenomena from the perception of those who underwent the experience (Giorgi, 1985; Moustakas, 1994; van Maren, 1990). Creswell (2007) stated that researchers seek to cultivate a greater understanding of several individuals' common or shared experiences of a phenomenon to develop practices or policies hence, best suited through phenomenology (p.60).

I used a transcendental phenomenology approach to explore and better understand high school students' experiences with metacognitive teaching strategies in introductory biology. Researchers value this theoretical approach as a method to examine the lived experiences of a phenomenon from the perceptions of those who experience them (Giorgi, 1985; Moustakas, 1994). The emphasis relies on looking closely at the lived experience in specific settings, rather than abstract theorizing about human nature, and on avoiding researcher bias or the levying of personal theories and experiences on the target group under study (King & Horrocks, 2010, pp. 181-182).

Role of the Researcher

Creswell (2009) stated, “particularly in qualitative research, the role of the researcher as the primary data collection instrument necessitates the identification of personal values, assumptions, and biases at the outset of the study” (p. 196). In this study, my role was that of an observer-as-participant. I was the primary instrument of data collection and analysis that collected, coded, and analyzed the data from interviews and classroom observations. The professional relationship I had with the study participants was as their former instructor. However, I did not use my former position to intimidate the student participants into divulging information that was not pertinent, nor did I release student interview responses.

However, it was the potential for bias on my part, which could have impacted the study's outcome, making it very challenging to be objective and nonjudgmental in my thoughts, observations, and actions. For instance, potential bias was my experience in science education, teaching, and research. I taught for 19 years and have conducted research intermittently since 2010. On the other hand, this assisted in data collection, inductive analysis, including understanding the process and phenomena. Also, I used epoché, bracketing observations, and memos while reporting and analyzing the data. I kept a personal journal to document my role and experiences throughout the entire process.

Methodology

Participant Selection Logic

Creswell (2007) proposed using from five to 25 people to interview for phenomenological studies so that the researcher can purposefully choose participants who generate an inherent understanding of the phenomena, not concentrating on the number of participants in the study (p. 119). The sampling frame for the study was 50 advanced placement (AP) biology students at a private high school in Long Island, New York. Most of these students met the school's criteria for admission into AP classes, which are: (a) general Biology and Chemistry courses with a cumulative average of 90%; (b) Trigonometry and Algebra or pre- Calculus with a cumulative average of 90%, and (c) a student must be either in the 11th or 12th grade. However, the headmaster has registered students who have not met the prerequisite grade point averages but have demonstrated high effort and fortitude within science and mathematics courses into AP Biology with a modicum of success.

Transcendental phenomenology requires a relatively homogeneous group of participants to identify and describe in-depth shared experiences within a group; a heterogeneous group constitutes a sampling limitation from a phenomenological perspective (Cilsez, 2010, p. 498). If extreme diversity existed in group experiences, then it would be problematic for me to find commonality in the experiences and the overall essence of their experience. Location affected the selection of participants because, in a phenomenology study, location is related to the essence of the experience. Creswell (2007) stated that "in a phenomenological study, the participants can occur at a single site" (p. 119).

Sample size in phenomenological studies must have a shared experience, including a comprehensive analysis of the lived experience. With these requirements in mind, I chose 20 students from a more extensive sampling frame of 50 students who would not drop out based on the rigor of the course. Creswell (2007) stated, "in phenomenology, the number of participants ranged from one (Dukes, 1984) up to 325 (Polkinghorne, 1989); however, Dukes (1984) recommended studying three to 10 students (p.126).

Hycner (1999) stated, "the phenomenon dictates the method (not vice-versa) including even the type of participants" (p. 156). This study used purposive sampling illustrated by Welman and Kruger (1999), meaning I chose the participants for the research (Babbie, 1995; Greig & Taylor, 1999; Schwandt, 1997), considering those who "have had experiences relating to the phenomenon" (Kruger, 1988, p. 150). The student participant sample requirement is (a) a cumulative average of 90% in the sciences (i.e., general biology and general chemistry); (b) a cumulative average of 90% in mathematics; (c) a prerequisite of algebra or pre-calculus, and (d) a student must be either in the 11th or 12th grade. A class enrollment of 50 students was the sample size for the study. The heterogeneity of grade level, even though nearly all students have advanced from elementary school to high school, provided for age differences and academic performance as covariates in this study.

In this transcendental phenomenological study, the relationship between saturation and the sample size is different. Lincoln and Guba (1985) recommend sampling until a point of saturation of redundancy is reached (Merriam, 1998, p. 64). However, purposeful sampling negated the saturation of random sampling because the framework was only information-driven. Consequently, purposeful sampling within this study will be based on interviews of each participant to gather copious amounts of information from their experience, thereby producing saturation based on information only. Therefore, "when the researcher sees thematic repetition, they conduct two or more interviews; if these are supportive of the developing thematic structure, no further interviews are necessary" (Sohn et al., 2017, p. 131). In summary, the pilot study invitation, primary study invitation, and the interview protocol are in Appendices A-C.

Instrumentation

In phenomenological studies, the approach to studying the phenomenon involves gathering data through interviewing only (Marshall & Rossman, 2006). The purpose of a phenomenological interview is to describe the meaning of a phenomenon that several individuals share (Arslan & Yildirim, 2015, p. 9). Dolbeare and Schuman designed "a series of three interviews that characterize phenomenology and allow the interviewer and participant to plumb the experience and place it in context" (Seidman, 2006, p. 17). The first interview focuses on participants' life history, which will give context to their experience with the phenomenon (Seidman, 2006, p. 17). The second interview centers on the participant reconstructing the current lived experience in the study area (Seidman, 2006, p. 17). In the third interview, the participants reflect on the meaning of the experience to make sense of the experience (Seidman, 2006, p.17). The study's interview questions are below:

Interview One: Focused Life History

1. Why did you register for AP biology?
2. How does your family play a role in your academic planning?
3. Please describe how you feel about science in general?
4. How were your past experiences in your science classes compare between middle school and high school?

5. Please describe your feelings about learning new scientific material. Are you happy, sad, frustrated, excited, intrigued, nervous?
6. How do you plan and prepare for new courses in school especially your science classes?
7. Does your family support your scientific endeavors if you are involved in any during school or as an extra-curricular activity?

Interview Two: The Details of Experience

1. How do you feel the metacognitive strategies improved your learning experience in AP biology?
2. In what ways do you feel they were effective in lecture and laboratory?
3. Describe a class period for lecture or laboratory using active learning and/or argumentation.
4. How did you and your partner or teammates feel (i.e., excited, anxious, curious, overwhelmed) while engaging in the activities?
5. Do you think the activities increased team(s) ability to set learning goals to work towards a common goal?
6. What are your thoughts about how the activities increased your self-efficacy (confidence) in biology?
7. Do you think the experience could be applicable in other areas of science for increased learning?

Interview Three: Reflection on the Meaning

1. How did the metacognitive teaching strategies make sense in other areas of your life? If not explain your feelings.

2. How did you feel about the activities whether in lecture or laboratory?
3. Do you think there were any limitations to using these strategies? Explain your feelings.
4. How can this experience lead to best learning practices in other subject areas for you? If it cannot, please explain why you feel it would not or cannot affect best learning practices?

I adapted these questions from Seidman's (2006) book, *Interviewing as Qualitative Research*.

Pilot Study

To test the feasibility of techniques, methods, questionnaires, and interviews and how they function together in a particular context, a pilot performed can also reveal ethical and practical issues that could hamper the main study (Fraser et al., 2018, p. 4). Additionally, as a biology educator working on her dissertation, I used metacognitive teaching strategies, and this professional exposure provided an understanding of metacognitive teaching strategies. Research studies on cognition in biology increased slightly from 2010; however, there are limited studies on students' experiences utilizing metacognitive teaching strategies (i.e., active learning and argumentation) in introductory biology. Subsequently, based on this desire to understanding students' thoughts and experiences with metacognitive teaching strategies, I planned to conduct a basic qualitative design with a transcendental approach.

Through achieving presuppositionless, that is transcendentality, the aim of this method was to provide relevant information about the context of the phenomenon (Creswell, 1998; Kim, 2016; Marshall & Rossman, 2006, Moustakas, 1994). In order to impart the experiences and perceptions about metacognitive teaching strategies, it was crucial to hear their views through in-depth interviewing. During preparation to conduct the study, one concern manifested which was ‘is the interview series appropriate for high students? Hence, I designed a pilot study to validate the three interview series protocol for the primary research study.

The primary study’s recruitment process used school Advanced Placement policy and course requirements for AP subject registration 2019–2020 which was as follows: cumulative average of 90% in the sciences (i.e., general biology and general chemistry; a cumulative average of 90% in mathematics; a prerequisite of algebra or pre-calculus, and a student must be in the 11th or 12th grade. However, the interview series took place after the May exam. Former AP Biology students received an invitation to review the interview protocol for language, age correlation, and comprehension.

Student participants and parents reviewed the study’s pilot assent/ consent forms which were two-page documents. If they consented, then the signed forms are returned for study files. Former AP Biology students 2017-2019 reviewed the interview series protocol for language, age correlation, and comprehension. Students will have one week to analyze and critique the three interview series protocol. They emailed their analyses to traci.collier@waldenu.edu. Then it was downloaded to a file on my password-locked computer. I stored the hard copies in a fingerprint-accessible safe. The study’s debriefing provided student participants and parents with a full explanation of the study’s phenomenon (metacognitive teaching strategies), procedures for metacognitive teaching strategies given to participants, and the reasons why they would need to engage in these activities.

Additionally, if any participant requested to speak to Dr. Bruckstein (school psychologist) about the study, this option was available. If the analysis of participant comments demonstrated a necessity to revise interview protocol, then I would proceed with a change of procedures request. If required, the student analyses and critiques of interview question protocol provided the rationale for changing the interview protocol. Student participants and parents will review the primary study's assent/ consent forms, two-page documents. If they consented, both forms are signed, and one returned for study files in fingerprint access safe. The emailed pilot study invitation and informed consent form in Appendices A and C .

Procedures for Recruitment, Participation, and Data Collection

The recruitment process was as follows: (a) a cumulative average of 90% in the sciences (i.e., general biology and general chemistry); (b) a cumulative average of 90% in mathematics; (c) a prerequisite of algebra or pre-calculus, and (d) a student must be either in the 11th or 12th grade. On the other hand, if the study encountered a reduction in the sample size of under ten, I would seek permission to interview the previous academic year's AP Biology students. However, I needed to prepare for specific threats to validity with this sample; for instance, maturation includes emotional, psychological, or physiological processes within study subjects which (across time) somehow affected the dependent variable (Campbell & Stanley, 1963, p. 5; Martella et al., 1999, p. 39).The study's participants interview sessions were audiotaped with their permission before the start of the study. The qualitative researcher was the primary instrument for data collection and protocol development in this study. The interviews length aligned with grade level and maturity (i.e., 11th grade = 1 hour and 12th grade = 1 hour).

Subsequently, the timeframe between each interview occurred between 2-3 days and no more than a week apart due to avoid experiment mortality. The interviews were recorded using a Sony ICD-UX560 audio recorder. In order to prepare for unforeseen technical issues, I purchased a second SONY ICD-UX560 audio recorder.

The in-depth interview data gathered from the study had varied protocols based on grade level. The interviews, including follow-ups, were transcribed then member checked as well as verified by the student participants. Afterward, horizontalization occurred, which means I underlined each statement and assigned a code or claim that illustrated the subject or theme that the sentence described (Moustakas, 1994). The rationale for horizontalization was to develop smaller clusters of thematic data for analysis.

The debriefing was a cardinal part of the consent process and required conducting interviews for a quantitative or qualitative research study. The study's debriefing provided student participants with a full explanation of the hypothesis tested, or phenomenon (metacognitive teaching strategies) studied procedures for metacognitive teaching strategies given to participants and the reason(s) why they needed to engage in these activities. It included other relevant background information about the study. The study's consent process includes pilot study invitation and primary study invitation, in Appendices A and B.

Data Analysis Plan

In the transcendental phenomenological study, data analysis began with the transcription of the three interviews verbatim per participant. The researcher sent transcribed interviews back to participants for a member check then proceeded to the next phase of analysis. Per the philosophical tradition, there are three stages of analysis: Phenomenological Reduction, Imaginative Variation, and Synthesis. The interview process correlated with the research questions by trying to understand the shared phenomenon of metacognitive teaching strategies in Biology. Afterward, I bracketed my subjectivity of preconceptions about the study, which was called epoche´. Epoch refers to putting aside the researcher's prejudgments and presuppositions towards metacognitive teaching strategies.

Phenomenological Reduction

During this stage, I initiated horizontalization of the data that means all relevant student expressions are listed and coded, then foreign student expressions are eliminated. These horizons are called the textural meanings (constituents) of the phenomenon referred to in Figure 7. Moustakas (1994) articulated " horizons are unlimited as well as horizontalization is a never-ending process" (p. 95). The data was translated then split into meaning units, thereby giving each theme its meaning. Textural language describes active learning and argumentation. The textural language described every aspect of how the participants experiencing the phenomenon. The textural language was then clustered and coded as the core themes of each participants' experience using active learning and argumentation (Moustakas, 1994). After constructing the individual textural descriptions, I revisited the transcripts to ensure that the descriptions exemplify the thickness and richness of the experience and the phenomenon. Lastly, I created a combined textural description.

Imaginative Variation

During this data analysis stage, I explored the variety of meanings of the experience of active learning and argumentation. Moustakas (1994) stated, “the aim is to arrive at a structural description of an experience, the underlying and precipitating factors that account for the phenomena experienced” (p. 85). During this stage, the process determined “how that speaks to conditions that illuminate the what of experience” (Moustakas, 1994, p. 85). By imagining the possible variations of textural characteristics, I was able to lead into structural descriptions. For instance, clear, concise instructions could be a significant theme in a student’s description of practical instruction in science leading to self-efficacy. Thus, suggesting as I imagined the numerous variations on meaning, I surmised that clear, concise instructions were a possible interpretation. Subsequently, I compiled individual structural descriptions validated through revisiting the transcripts, and then I combined them to create a collective structural description.

Synthesis of composite textural and structural descriptions. At this stage, I examined and synthesized to illustrate the essence of the student participants' shared experience (shared meaning units). I created two narratives for each student participant. The student narratives illustrated a textural, and the textural description illustrated the experience has occurred, and a structural description means how it has occurred. Also, I eliminated any single student participant, meaning units, to develop a complete combined narrative of the phenomenon's essence. In so doing, it led me to develop a third narrative that represented an in-depth description of the experiences of the phenomenon, which depicted the essences of the experience. Upon further reflection, the commonality amongst the textural and structural descriptions led to the essence of metacognitive teaching strategies and students' perceptions of whether they enhanced conceptual change, learning, and self-efficacy in Biology. Moreover, if there were discrepant cases and contradicting data, I addressed this issue by asking the student participants to further explain during the following interview.

Issues of Trustworthiness

Internal Validity

A specific and detailed approach, outlined in Chapter 3, was exercised in the study to ensure trustworthiness. Using Lincoln and Guba's (1985) validation strategies, the study utilized credibility, transferability, dependability, and confirmability. I read extensively on qualitative trustworthiness to establish a reliable method of data analysis.

Credibility

In qualitative research, internal validity "deals with the question of how research findings match reality. How congruent are the findings with reality?" (Merriam, 1998, p. 201). In contrast, Ratcliffe (1983) postulated that "data do not speak for themselves; there is always an interpreter or translator as well as one cannot observe or measure a phenomenon/event without changing it" (pp. 149-150). To ensure internal validity, here are "six strategies to enhance internal validity: (1) triangulation ; (2) member checks; (3) long-term observation; (4) peer examination; (5) participatory or collaborative modes of research, and (6) researcher's biases" (Merriam, 1998, p. 205). In phenomenology research, internal validity is transparent and articulated at the onset of the study. There is two methods (1) subjectivity statement, which depicts the researcher's suppositions and prejudgments, and (2) epoche´, which displaces presuppositions and prejudgments throughout the study.

External Validity

Transferability

Lincoln and Guba (1985) “transferability is the degree to which the results of qualitative research can transfer to other contexts or settings with other respondents. I facilitated the transferability judgment by a potential user through the full description. I provided a complete description of the phenomenon to give as much detail to my audience, which ensured an accurate representation of the phenomenon from the participants’ perspective.

Dependability

The study’s dependability required the stability of its findings over time. It involved participants’ evaluation of the findings, interpretations including study recommendations, supported by the data received from study participants. It included the aspect of consistency. The sanctity of dependability depends on the audit trail, which provides transparency of the research process.

Confirmability

Confirmability involved objectivity throughout the study; hence, the inclusion in the audit trail for transparency. Moreover, reflexivity ensured critical self-reflection about me as a researcher, the relationship between myself and the participants, and how the relationship affected the participants’ responses during interviews. Furthermore, it was the degree to which other researchers confirmed the findings—also dealt with establishing whether the data and interpretation of findings are not erroneous but derived from the study’s data collection.

Ethical Procedures

Ramos (1989) described three types of problems that may affect qualitative studies: the researcher/participant relationship, the researcher's subjective interpretations of data, and the design itself. Several research studies have indicated three prevalent ethical issues: autonomy, beneficence, and justice (Orb et al., 2001, p. 95). In this study, autonomy was handled through informed consent, making a reasonable balance between over-informing and under-informing (Kvale, 1996). In other words, student participants could exercise their rights as autonomous individuals to accept or refuse to participate in the study.

Consent was "negotiation of trust, and it required continuous renegotiation (Field & Morse, 1992; Kvale, 1996; Munhall, 1988). Further, beneficence means doing good for others and preventing harm — beneficence was demonstrated through confidentiality and anonymity concerning statements or personal information. Lastly, the participants avoided being exploited or abused within this study illustrated justice through equal sharing and fairness. A school letter of cooperation from the headmaster, principal, and trustees to conduct a qualitative study was issued. I received authorization from the Institutional Review Board (IRB) at Walden University.

All participants, parents, and administrators received informed consent forms. These forms were reviewed and signed before the start of the study. In contrast, if any participant declined to participate, I have planned to complete a Request for a Change in Procedure from the IRB at Walden University. Also, the anonymity of data, transcriptions, and notes stored in a password-encrypted computer file, as well as files, are in a fireproof lockbox. My committee members and I had the passwords and lockbox keys for data retrieval. The data and materials are secured and stored for five years before disposal.

Summary

In this chapter, I outlined a basic qualitative design with a transcendental phenomenological approach to data analysis. I developed qualitative questions to understand the students' perceptions of active learning and argumentation as metacognitive teaching strategies and whether they affected their learning of introductory biology. I discussed my role as a researcher within the high school and identified protocols utilized to obtain participants. The methodology section included participant selection logic, instrumentation of researcher-developed interview questions, participants recruitment, participation and data collection, and a data analysis plan. Lastly, I examined issues of trustworthiness and the ethical issues for researching within an educational setting. Furthermore, in Chapter 4, I analyzed the data collected to portray the essence of the phenomenon.

Chapter 4: Results

This chapter presents the findings of a basic qualitative design with a transcendental phenomenological approach interpreting students' opinions, perceptions, and experiences concerning metacognitive strategies for their introductory biology learning. The research questions were:

RQ1: What are secondary school students' perceptions about metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology?

RQ2: What are secondary school students' experiences with metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology?

I conducted an initial semi-structured interview and two follow-up interviews to explore student responses. Chapter 4 contains the pilot study, study setting, participants' demographics, and data collection processes. Further, the chapter includes the methodology utilized to address the evidence of trustworthiness, a comprehensive description of the results, and a final summary.

Pilot Study

Previous AP Biology students from 2017–2019 participated in a pilot study to validate the three-series interview protocol for the primary research study. The premise was to identify any interview series questions that may be confusing or raise concern. I emailed a general invitation (Appendix A) and received one participant's response to participate in the pilot study. The participant signed and returned the informed adult participant consent form. However, the participant served as an active member of the

Israel Defense Forces (IDF) in March 2021; hence, the participant was unavailable to participate in the pilot study due to service duties. Since I had received no other responses to participate in the pilot study, I proceeded with distributing the primary study invitations (Appendix B) without any modifications to the three-series interview protocol.

Setting

The setting for this study was ABCA high school (ABCAHS) a private religious school situated within a public school district in Long Island, New York. The high school population is 411 students with 51 instructional faculty members. Table 2 illustrates the enrollment by grade level. The high school has integrated religion and secular studies for a well-rounded educational experience. I selected the school for this study due to the school's rigorous academic undertakings as well as the school's objectives of identifying a student's ideal learning style and creating those experiences for him or her that affect utmost intellectual, social, and emotional growth.

Table 2

Enrollment by Grade

Grade Level	9	10	11	12
Students	108	109	113	81

Note: Adapted from National Center for Education Statistics (2021). Retrieved from https://nces.ed.gov/surveys/pss/privateschoolsearch/school_detail.asp?Search=1&Zip=11514&Miles=10&SchoolPageNum=3&ID=A0302278

Initially, I planned the study to occur in the principal's conference after school with an initial face-to-face interview, then subsequent interviews occurring every 2 or 3 days and/or no more than one week apart. The planned setting for the study was modified due to COVID-19 pandemic effects on school operations and to accommodate for COVID safety procedures. For example, the school's protocols included reducing the number of personnel or visitors and modified class schedules. The COVID-19 pandemic made it necessary to conduct the study via Zoom video conferencing as per the school's safety procedures. The recruitment remained the same, which was to contact former student participants via email.

Thirty former students from 2017–2019 received the pilot study email invitation and informed consent forms; however, I received only one response. I believe the paucity of responses for the pilot study was due to the pandemic or noninterest in participation. The primary study email invitations and informed consent forms were sent out to 30 former students from 2019–2020, asking for their participation, resulting in three responses. The three former student participants met the criteria as described in Chapter 3. The semi structured three series interview protocol proposed face-to-face interviews to occur within 2 to 3 days each other and/or no longer than a week apart due to COVID-19 safety procedures; the semi structured three series interviews occurred via Zoom conferencing once a week based on the former student participants' schedules and activities.

Demographics

Three former AP biology high school students participated in this study as an illustrative student sample for introductory biology courses at ABCAHS (Table 3).

Table 3

Study Participant Demographics

Participants	**Grade**	**Gender**	**Age**
1	12	Male	17
2	12	Female	18
3	12	Male	17

Similarly, as shown in Table 4 and Table 5 the participants are representative of the ethnic and gender subgroups enrolled at ABCAHS.

Table 4

Enrollment by Race/Ethnicity

	American Indian/ Alaska Native	Asian	Black	Hispanic	White	Native Hawaiian/Pacific Islander	Two or More Races
Students	0	0	0	0	411	0	0

Note: Adapted from National Center for Education Statistics (2021). Retrieved from https://nces.ed.gov/surveys/pss/privateschoolsearch/school_detail.asp?Search=1&Zip=11514&Miles=10&SchoolPageNum=3&ID=A0302278

Table 5

Enrollment by Gender

Male	238
Female	173

Note: Adapted from National Center for Education Statistics (2021). Retrieved from https://nces.ed.gov/surveys/pss/privateschoolsearch/school_detail.asp?Search=1&Zip=11514&Miles=10&SchoolPageNum=3&ID=A0302278

Likewise, the student participants and enrollment are illustrative of school's surrounding area (Table 6). Also, all participants have been student peers from elementary to high school. In this study, the three participants will be referred to as P1, P2, and P3.

Table 6
Area Population by Race

Race	Population	Percentage
Asian	1,107	10.85%
Black or African American	151	1.48%
Some Other Race	320	3.14%
Two or More Races	86	0.84%
White	8,541	83.69%

The rationale behind the illustrative sample was because the National Research Council cited 115 and 120 studies about metacognitive teaching strategies have been conducted for physics and chemistry, respectively, but only 17 studies were published between 2001 and 2010 to analyze cognition in biology (Singer et al., 2012; Zohar & Barzilai, 2013). As a science educator, I am interested in understanding high school student perceptions and experiences with metacognitive strategies (i.e., active learning and argumentation) as valuable methods for conceptual change and learning in introductory biology.

Data Collection

Data collection processes included developing protocols, recruitment of participants, and communication. The IRB required a letter of cooperation from the partner organization before participant recruitment. Participants were recruited for the pilot and primary studies through electronic invitation following the partner organization and IRB approval. The pilot and primary study invitation outlined the eligibility requirement and that the informed consent forms were accepted electronically. The eligible participants for the pilot study were former AP Biology students from 2017–2019, whereas the eligible students for the primary study were former AP Biology students from 2019–2020.

It was not mandatory to participate in the study, but if the students met the requirements, they received an invitation. Subsequently, of those who were invited and eligible, one participant responded for the pilot study and three participants responded for the primary study. The pilot study could not be conducted because of the participant's military obligations. The primary study interviews took place over a 5-week period that began on May 2, 2021, and concluded on May 31, 2021. The participants chose a date and time for Zoom conferencing as per their schedules.

The Three Interview Series

Seidman (2006) stated, "People's behavior becomes meaningful and understandable when placed in the context of their lives and the lives of those around them. Without context there is little possibility of exploring the meaning of the experience" (p.17). In the first interview, the interviewer's task is to put the participant's experience in context by asking him or her to tell as much as possible about themselves in light of the topic up to the present time (Seidman, 2006, p. 17). The first interview conducted with each participant was the *Focused Life History* which was meant to elicit the context of the participants' experience through the reconstruction of why they registered for AP Biology, family involvement in academic planning, their earlier scientific educational experiences, and their feelings towards science in general.

The purpose of the second interview was "to concentrate on the concrete details of the participants' present lived experience in the topic area of the study" (Seidman, 2006, p. 18). The second interview conducted with each participant was the *Details of the Experience*, which elicited the participants' learning experiences with active learning and argumentation and if these teaching strategies increased their self-efficacy, and whether the strategies were applicable in other areas. For the third interview, "we ask participants to reflect on the meaning of the experience" (Seidman, 2006, p.18). The third interview conducted with each participant was the Reflection on the Meaning elicited the participant's understanding of their experiences with metacognitive teaching strategies (i.e., active learning and argumentation).

The three series of interviews averaged a total time of 25–30 minutes and took place on Zoom with personal access codes. The time frame between each interview occurred 2–3 days between and no more than one week apart. Each participant received a transcript for member-checking within a week of the interview. I recorded the interviews using a SONY ICD-UX570 audio recorder and Zoom video conferences with personal access codes. My password-secured laptop is the location of the audio recordings and Zoom video recordings.

There were two variations in data collection. First, Participant 3's interviews did not follow the three-interview series structure. The second and third interviews with Participant 3 were merged. The rationale behind merging protocols was based on the availability of Participant 3. Second, Participant 1 did not return for interviews two and three. I sent several emails to seek another time for the interviews but he/she did not respond to my emails. In conclusion, the interviews were scheduled during a timeframe of students taking AP exams, final exams, and graduation which may be seen a high-level stress period for high school students.

Data Analysis

Per the transcendental phenomenological tradition, the stages of analysis were as follows: epoché, bracketing, phenomenological reduction, imaginative variation, and synthesis of composite textural and structural descriptions. The progression through these stages led the researcher to the essence of the experiences, which in this case is a description of the essence of active learning and argumentation from the perceptions of high school students.

After transcribing the data to begin my analysis, my first step was to employ the epoché, that is putting aside the researcher's prejudgments and presuppositions towards active learning and argumentation. The list of biases and preconceptions utilized for relinquishing all biases and preconceptions were as follows:

1. Students are only interested in grades not learning.
2. Every student is passionate about Biology or science in general.
3. Every student is passionate about learning, especially sciences.
4. Lack of Guidance does not exist in the classroom.
5. All students like differentiated instruction and/or change.

I believe that this process was beneficial to the data analysis and being receptive to opinions and perceptions contrary to my own regarding science education, instruction, and learning.

Bracketing the Phenomena

Trumbull (1993) stated, "Bracketing is what I have already done, that is, the selection and developing of the topic, the area of study, the phenomenon under investigation. I must confine myself and the co-researchers solely to the experience of the phenomenon" (p. 92). I implemented bracketing by only focusing on the participants' experience essential to active learning and argumentation. Further, I examined all viewpoints, experiences, and opinions of the students' experiences with active learning and argumentation metacognitive teaching strategies in introductory biology.

Phenomenological Reduction

Horizontalization: During this stage, I initiated horizontalization of the transcripts verbatim, which were analyzed for significant, relevant, and non-overlapping statements ascribed to students' experiences with active learning and argumentation. The verbatim transcripts for each participant are in Appendices A and B. Moustakas (1994) stated, "illustrates the importance of being receptive to every statement of the co-researcher's experience, granting each equal comment value" (p. 122). Next, I read the transcripts looking for meaningful statements which specifically referred to the phenomenon. These meaningful statements are called horizons or textural language. In this study, I will utilize 'textural language' instead of horizons. The textural language described active learning and argumentation. The textural language described every aspect of how the participants experienced the phenomenon.

Subsequently, I pondered the following two questions for each participant, 1) "Does it contain a moment of the experience that is necessary and sufficient constituent for understanding it?" 2) "Is it possible to abstract and label it?" (Moustakas, 1994, p. 121). The textural language was coded into meaning units then clustered to illustrate the emergent themes of each participants' experience using active learning and argumentation in Appendix C. I created an individual textual description for each participant. I returned the transcripts to ensure that the descriptions embodied the thickness and richness of the experience and the phenomenon. Moustakas (1994) guides the researcher in this process by stating that in forming composite textural descriptions, the invariant meanings and themes of every co-researcher are studied in depicting the group as a whole (p. 137-138). As a final point, I reviewed the individual textural descriptions; then, I synthesized all textual descriptions into a composite textural description.

Imaginative variation. During this stage of data analysis, I utilized the textural description to explore the diversity of meanings of the experience of active learning and argumentation. Moustakas (1994) stated, “the aim is to arrive at a structural description of an experience, the underlying and precipitating factors that account for what is experienced.” (p. 85). During this stage of data analysis, the process was to determine “how that speaks to conditions that illuminate what of experience” (Moustakas, 1994, p.85). I imagined the possible variations of textural characteristics, which lead to structural descriptions. For example, when analyzing both interview transcripts and textural descriptions active learning and argumentation are beneficial to learning as well as increasing understanding appeared to be a major theme in their descriptions of active learning and argumentation. This was made clear by each participant describing the metacognitive teaching strategies as beneficial regardless of his/her preference. Furthermore, the structural descriptions were created then supported by revisiting the transcripts, then the composite structural description was developed which included both participants.

Synthesis of composite textural and structural descriptions. At this stage, I examined and synthesized the composite textural and structural descriptions to explicate the essence of the participants’ shared experiences (shared meaning units). I created two narratives for each participant. A textural description illustrated the experience that occurred; then, a structural description illustrated how it occurred. Likewise, I compared and analyzed the composite descriptions; in doing so, I created a third narrative to represent the essence of perceptions and experiences. Furthermore, upon further reflection, the commonality amongst the textural and structural descriptions lead to the essence of active learning and argumentation and students' perceptions on whether they enhanced conceptual change, learning, and self-efficacy in Biology. There were no discrepant cases and/or contradicting data.

Evidence of Trustworthiness

A specific and detailed approach, outlined in Chapter 3, was exercised in the study to ensure the trustworthiness of the study. Using Lincoln and Guba's (1985) validation strategies, the study utilized credibility, transferability, dependability, and confirmability. I read extensively on qualitative trustworthiness to establish a reliable method of data analysis.

Internal Validity

Credibility

Lincoln and Gaba (1985) suggest that credibility is the equivalent of internal validity in quantitative research and is concerned with the aspect of truth-value. To establish credibility of this study, I employed "six strategies to enhance internal validity" (Merriam,1998,p. 205). The six strategies were: (a) triangulation, (b) member checks, (c) long-term observation, (d) peer examination, (e) participatory or collaborative modes of research, and (f) researcher's biases. In this transcendental phenomenology research, internal validity was transparent and articulated at the beginning of the study. Additionally, internal validity within this methodology occurred at the onset with epoche´, which displaced presuppositions throughout the study. I chose to utilize epoche´ in the beginning and throughout the study.

Triangulation

Triangulation is one method by which the researcher analyzes data and then presents the results to others to understand the experience of a common phenomenon (Denzin, 1989). The researchers can be confident if the phenomenon described in the interviews is the reality of the situation, as perceived by those in it, is being conveyed as truthfully as possible (Merriam, 1995, p. 55). I engaged in persistent observation by rereading the transcripts, horizontalization, and then recoding, leading to theme development and textural and structural descriptions. Subsequently, data triangulation used the same instrumentation for interviewing the participants, each one at different times. Thereby, the cogency of the participants' descriptions increased because their descriptions remained the same over five weeks.

Member Checks

Attentive and purposeful member checking ensured the verbatim transcripts were accurate and consistent with students' perceptions and experiences of active learning and argumentation. Lincoln and Guba (1985) described member checks as "the most crucial technique for establishing credibility" (p.314). In this study, the verbatim transcripts were returned for the participants to check the accuracy of their experiences. The participants received their verbatim transcription to correct any misconceptions and returned it if there were applicable changes. However, the participants were unavailable for the final member check, including textural and structural descriptions. P2 was on an international religious retreat, and P3 had a one-year theological program that did not allow communication via electronics in Israel.

Long-Term Observation

Merriam (1995) stated “observational data represent a firsthand encounter with the phenomenon of interest rather than a secondhand account obtained in an interview” (p.13). As a 22- year science educator I had previously observed this phenomenon firsthand as a biological science instructor.

Peer Examination

I did not have a peer examine this study because I was the only teacher in my department utilizing transcendental phenomenology methodology.

Participatory or Collaborative Modes of Research

The purpose “is to arrive at evaluation conclusions due to a consensus among persons from different perspectives about the program” (Lynch, 1996, p. 62). I shared my findings with my mentor and two former undergraduate students familiar with introductory Biology and educational research at different phases in the study. Their comments and viewpoints were astute and informative such as a) should have had more probing questions, b) added a qualitative survey, and c) practiced interviewing.

Researcher’s Bias

In transcendental phenomenology, the researcher engages in epoche´ throughout the study to ensure a non-biased examination and interpretation of the student's perceptions and experiences with active learning and argumentation. "He/she should try to stick to the ethical rules and principles, perform the evaluation as accurately as possible and report the findings honestly" (Zohrabi, 2013, p. 259).

External Validity

Transferability

In this study, transferability was essential to the result's applicability to a broader audience. Lincoln and Guba (1985) describe thick description "as a way of achieving a type of external validity by describing a phenomenon in sufficient detail one can begin to evaluate the extent to which the conclusions drawn are transferable to other times, settings, situations, and people" (p. 308). In this study, I provided composite textural and structural descriptions of the phenomenon, which led to an in-depth description of the essence of the participant's perceptions and experiences.

Dependability

The dependability of a study "refers to the consistency and reliability of the research findings and the degree to which research procedures are documented, allowing anyone outside of the research to follow, audit, and critique the research process" (Moon et al., 2016, p. 17). The study's audit trail explained how the data was gathered, analyzed, developed themes, and attained the results. As a result, the preceding detailed information would assist in replicating the research along being conductive to its reliability.

Confirmability

According to Guba and Lincoln (1989), to establish confirmability, credibility, transferability, and dependability must be achieved. Confirmability within this study involved objectivity through the audit trail, and the audit trail illustrated a detailed description of data collection and analysis. Likewise, I consistently reevaluated my biases and personal experiences with the metacognitive learning strategies throughout the study.

Bracketing the phenomenon before and to the end of the study, I maintained an open mind to see and experiences from the participants' eyes.

Ethical Procedures

Creswell (2007) stated, “ a qualitative researcher faces many ethical issues that surface during data collection and in analysis and dissemination of qualitative reports” (p. 141). In this study, three ethical issues addressed are autonomy, beneficence, and justice (Orb et al., 2001, p. 95). An established balance between over-informing and under-informing sustained the participants’ autonomy (Kvale, 1996). The participants understood that it was their right to participate or refuse to participate in the study. Similarly, confidentiality and anonymity illustrated beneficence. Justice within the study derived from equal sharing and fairness, which eliminated the participants from being mistreated and/or subjugated.

To conduct this study, I received a letter of cooperation from the headmaster, principal, and board of directors. The IRB authorized the study to proceed. All participants and parents received an invitation and informed consent forms, and these forms were reviewed and signed before the pilot and primary studies. There were no participants who refused or declined the study’s invitation. However, a deviation was that one participant did not return for interviews two and three. A locked file cabinet and password-protected laptop in my home office stored all data. The committee chairperson and methodologist will be the only others with access to the study’s data. The study’s data disposal will occur in five years.

Results

The research questions for this study were: (a) What are secondary school students' perceptions about metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology? and (b) What are secondary school students' experiences with metacognitive teaching strategies for achieving conceptual changes and learning in introductory biology?

Textural Description

Textual descriptions revealed during horizonalization, which described in the textural language (i.e., significant statements) the phenomenon as it emerged during the in-depth interviews, returning to the experience free of assumptions, and describing it again and again (Moustakas, 1994). These statements connected to the phenomenon through analysis, and each statement denoted equal value. The horizon statements developed into units of meaning and eliminated irrelevant or overlapping statements.

The units of meaning clustered into themes then were utilized to create textural descriptions for each participant. The themes identified were (a) awareness of active learning and argumentation increasing comprehension; (b) active learning and argumentation utilize, real-life events for understanding and comprehension; (c)interactive teaching vs. passive teaching affects how students engage and learn in science classes; (d) peer perception, acceptance, and expectations in group work; (e) transferable skills, and (f) active learning and argumentation increased self-efficacy (confidence) in AP biology.

Theme 1: Awareness of Active Learning and Argumentation Increasing Comprehension

The theme 'awareness of active learning and argumentation increasing comprehension' focused on how the participants described active learning and argumentation as beneficial to learning and comprehension introductory biology. The participants elicited a correlation between (a) educators should facilitate strategies to increase student comprehension and engagement and (b) student use of active learning and argumentation depended on learning style for increased comprehension, which developed as subthemes.

P2 believed active learning and argumentation were beneficial to learning and understanding introductory biology or her AP Biology exam, "so, right, I think the argumentation that we did was beneficial because I think that's the best way to learn. To know if you fully understood a topic." Furthermore, P2 felt the experience increased her understanding and comprehension, "I think, me and my classmates benefitted from this experience. I think active debate was beneficial to the overall comprehension of the topics."

Of the two participants it was P2's viewpoint on the ability to articulate in your own words signified comprehension, "But the next step of like really, truly understanding it is to uh repeat it in your own words." Lastly, P2 felt argumentation increased student engagement in learning the content,

> I think it was exciting to have like a lively debate and be able to work it out amongst yourselves. I would say it was exciting and it helped us really get involved in the topic. We were able to figure it out looking at the people's

> symptoms then we knew what contaminated the Tylenol and caused sickness and death. They were poisoned with cyanide and how that affects the mitochondria.

P3 voiced, “Yeah, so for the most part it’s definitely beneficial to like grasp concepts.” however, P3 differentiated on why active learning (hands-on) was more beneficial than argumentation for his/her learning style. P3 expressed,

> But like I know for me the labs were fun because like I saw it as a fun activity then like also like oh wow, we just learned this like this is Cool! So, like I like labs because it reinforced what we just learned in lecture. And you know actively think while doing them, so I think labs over case studies.

Next, P3 vividly recalled an active learning hands-on laboratory,

> Ok, there was a lab, but I only remember it so vividly because it smelled so bad. The lab with the fake vomit. We were trying to see what foods were digested. Oh, it smelled so bad and the color, Ms. Collier! And everybody was like engaged. It was also like funny, so like nobody was like, oh we don’t want to do this. We sat there working and laughing. We found our victim’s last meal based on the contents of the throw up. If I remember we were studying macromolecules, right?

Similarly, even though P3 felt argumentation was an intense process nevertheless he/she respected the process. P3 passionately described the argumentation process,

> I mean yeah, it was but you definitely capitalize on this method because you would say it in a way like as if, like you would question us like you would start interrogating us like, do you actually know what I’m talking about? Or are you just saying you know? You know like you would like deep down drill in the concept and be like don’t give me no shenanigans! Do you understand it? We

> would answer correctly based on what we were doing, and you would say are you sure? Are you sure? we would answer confidently based on what we know but you would interrogate us at times. A lot I should say (laughing).

In conjunction, P3 described the case studies as more like homework assignments which were not as fun as the hands-on laboratories, "I mean, I guess you have to give homework like in every category, but like I know for me the labs were fun". However, P3 voiced that the case studies actually served as a checkpoint for understanding, "but, the case studies are kind of like for some students to see like what they know. Also, what they're like engaging more into and like what to focus more on."

Additionally, active learning as articulated by P3 allowed him/her to be a kinesthetic learner,

> I'm a very hands-on learner. … And like I thought that was very important for me because like I like to learn, but I also like to get my hands dirty in what I just learned because I know in that way. …I have to study for the test less because I have an example to go to and I'll also understand it more, you know.

Subtheme: Educator Should Facilitate Strategies to Increase Student Comprehension and Engagement. Both participants mentioned educator involvement in the classroom when utilizing the metacognitive teaching strategies. P2 articulated it was necessary for the teacher as a knowledgeable source to facilitate the classroom argumentation for clarity and direction,

> I think they were more effective in lecture because I think, uh that you as the teacher was able to monitor the conversation and like steer us into the correct direction with the case studies so if we were doing it by ourselves then students

> would get confused, it would be a little difficult to try to work out by ourselves but when you have someone who's knowledgeable like the teacher to navigate you around a certain topic. I think that works much better and then you get to really experience it, but also have the added benefit of having some guidance.

P3 described how it was important to have diagrams throughout the lesson,

> So, lectures, uh, you know you'd always have diagrams out, so like it would be important to see what you're talking about. … we would have to draw diagrams in our notes that kept us listening because we needed to know what was going on in the diagrams and how it connected to the lesson.

Subtheme: Student Use of Active Learning and Argumentation Depended on Learning Style for Increased Comprehension. Similarly, both participants voiced that active learning and argumentation were both alright, however, each participant stated why students would choose one over the other for learning. *"*I mean, I guess it depends on the person. For me, I don't think it would. I don't think it has ever negatively impacted me, but I guess somebody that learns better in different forms might not benefit from it. Actually, yeah, personally it was very beneficial to me*",* stated P2.

P3 articulated an understanding that the case studies were given as a checkpoint for certain classmates within their class period based on how they learn,

> But I have to say like it's that everybody learns in a different way. … So, I mean every kid learns differently, like of course if you have like a 10 out of 10 student and you give him a case study. I'm sure he'll learn from it. …but the case studies

are kind of like for some students to see like what they know. Also, what they're like engaging more into and like what to focus more on?

Theme 2: Active Learning and Argumentation Utilizes Real-Life Event for Understanding and Comprehension.

The 'active learning and argumentation utilizes real-life events for understanding and comprehension' centered on the participants' experiences in lecture and laboratory. The participants articulated active learning (i.e., case studies and laboratories) and argumentation which involved real-life events were good to measure whether they understood and/or comprehended certain content areas.

P2 stated,

> So, uhm, I really like how we would learn. We would learn a very broad topic and then we would be using the case studies for a very specific topic. I really like how it was applicable to everyday life. So, with the case studies especially the Tylenol one where we had to learn what the symptoms meant and what went wrong. I thought that was very interesting and helped overall understanding of cellular respiration at the organelle level and what it does to the whole organism. Then definitely breaking up into groups and debating and having to defend my position was helpful in learning.

Unlike P2, P3 liked the hands-on active learning more than the argumentation,

> Oh, I remember a lab we did on what is in nail polish. We looked all the chemical structures for regular nail polish versus gel nail polish. I never knew like that many differences are because of a small change in structure until we built the models. Oh, there was a similar with models on what affects proteins and at what

> level then we built models for all the levels of a protein. So, like it was helpful to see what you are talking about and like building it helped me to understand like you said hundred times structure and function.

Theme 3: Interactive Teaching vs. Passive Teaching Affects How Students Engage and Learn in Science Classes

The theme 'interactive teaching vs. passive teaching affects how students engage and learn in science classes' described by each participant the effects of differentiated instruction on learning in science classes. P2 articulated, "I think we definitely were able to learn in a better way than just being taught the lesson and just listening. …It's one thing to listen to a teacher speak and to just absorb". P3 explained what it means to experience active learning (hands-on) activities,

> And for labs I feel like yeah, just hands-on experience that just gets the cognitive like the mindset like your just your brain is actively involved because like your hands were doing your eyes are observing like all your senses are involved in the assignment. So, like you're getting a good grasp for the concept.

Subsequently, P3 conveyed there was one class with the same format as AP Biology that was interactive as well as engaging the students with a mini lecture then a laboratory to demonstrate understanding of how to utilize coding with a particular result,

> I mean really the only class I could think about that we had the same, uh, like structure of learning is engineering like, I really can't think of any other class because engineering it's very conceptual. What I mean there are different ways to understanding something in engineering so basically, we would learn to code then the teacher would say oh, now with what I just taught you I want you to turn on

> the lightbulb. You have 10 minutes to turn on the lightbulb by plugging it into your computer and turning it on then make it flash two times. So, at the end like nobody had the identical code like that's near impossible. So, like we would have these like I could them lab. He would have these labs to like to see what's working for you like it didn't matter what the next person was doing but it was like what is working for you in class.

Further, P3 postulated using active learning and argumentation can have limitations based on a rare type of student that likes passive teaching,

> Limitations, hmm I mean, the only one I can really think of is that those rare students who they like the boring lectures and like they can just sit down like I guess it's taking away from them. But then again, those are like rare. I don't come across many of them, straight robots who can like sit down and listen to words.

Theme 4: Peer Perceptions, Acceptance, and Expectations in Group Work

The theme 'peer perceptions, acceptance, and expectations in group work' illustrated the participants' opinions and experiences with team members using either active learning or argumentation. P2 described how her team worked during active learning and argumentation. For example, "I think how it's usually works one person will take the initiative and take the leadership and then everybody else will kind of take their role as like debating a certain topic" (see Table 2). Next, P2 described how the roles form within her team, "Somebody who's knowledgeable in something and then another person who's knowledgeable on something else. And then it'll kind form like a group with uh like roles to solve the problem".

P3 described their experiences and differences between their laboratory team vs lecture team then how each team affected their experiences with active learning.

> Right, so uhm, we had like an official lab group like, oh I don't remember who it was, but it was four and I remember like I don't want to say any names but like one or two kids were like kind of not interested as me and the other kid, so it was taking away from the experience. But, like, uh that was only on Friday.

Next, P3 expressed his/her perceptions, expectations, acceptance of their peer teams,

> So, like for the weekdays, we would have me, Daniel, Gilad, and Theo. We all understood each other and how we learned so we kind of understood how we should attack a problem. …so, I feel like obviously when you go to college like you're not going to know as many people but like at least for high school it's really those groups that you make are very important. You have like an understanding or awareness of is this kid compatible with this kid like are they going to work together or is this one going to sit down and let the other one does all the work, you know? I think the group make up is very important like who your teammates actually are?

On the other hand, P3 articulated that he/she expected a teammate to acclimate to their second laboratory period after being allowed to take a break due to personal problems.

> Ok ,so yes, running with one Friday, like somebody in my group whatever they're having a bad day. They were the person who writes all the stuff down. So, like ok, whatever I will write the stuff down for lab. So, I figured by the second lab period, it was like stupid but whatever she'll feel better but then she kind of affected the group to the point uh that some were like whatever let's just be out of

> it. She was like whatever since I'm not, let's just all be out. So, like I remember that was one time that was frustrating, but it was like was fine. Like I understand she was going through some stuff. So, it's like I forgave it. Like forget it but that was one time yeah.

Theme 5: Transferable Skill

The theme 'transferable skills' derived from both participants' own experiences and opinions about the usage of active learning and/or argumentation in another content area or as an option in their post-secondary education. For example, P2 stated,

> Ok, so yeah, the method of active learning definitely translated to my other classes, so specially in my English class we had something called book trials where there was a pro and con side to a book. Our team had to read, annotate, and analyze a classic novel from any genre. Basically, we said that a book that we were reading was not appropriate for private schools. So, I then used the argumentation methods that we learned in your class to basically prove my point in English.

P2 further articulated his/her usage of the metacognitive teaching strategies in other content areas in school,…

> Right, so yeah, I definitely think, uhm math, I'm a very visual person. So, making diagrams of whatever we were learning definitely helped especially you could see it written out but then in history it was used to produce timelines for a series of events which was helpful. For example, if it's like global history, you differentiate like at the same time period what was happening in Europe and in America.

P3 expressed throughout our interview that active learning especially the ability to either perform hands-on or real-life examples applicable to the course content was their ideal way to learn. For instance, "Like when I was applying to college like I wanted to see like what colleges offer that hands-on experience and also like in the business field. One of the main schools that is notorious for doing that is Michigan Ross". P3 further elaborated on how the university for their freshman year fall 2021 has active learning integrated into the business curriculum,

> Yeah, for sure 100% um so the school I'm going to like a lot of professors and guest lecturers (volunteers) have jobs in the business field. So, like they work in the city then come teach the students using real-life business examples. Like I'm very big on you can't learn business from a teacher alone. You have to learn business from a businessman or businesswoman. So, if you're going to ahead and think that you can learn business from a teacher or maybe you'll get it, but you are not going to fully understand it, so there's a lot of businessmen and women who after work come and teach the students. Like they're not just lecturing but they're teaching actual business. They're doing and analyzing real time examples and then showing how it applies but they are showing us like I just did this today and now tomorrow I have to do this. They are getting the kids involved in what they're working with during the day. I think that's really cool because again you're learning from someone who is actually doing it, not from someone who says I can teach you how to do.

P3 voiced that active learning and argumentation would be effective in other subjects that were highly conceptual,

> Yeah, definitely. I don't know so much chemistry because it is what it is in chemistry. It is what is at that point. Like it's more facts, you either get it or you don't, but physics it's a little bit between bio and chem. Like there's a lot of concepts where if you don't see actual examples, your kind of just going to be like oh ok, I guess. But that's OK, I guess mentality, yeah? As physics gets more complicated and you truly don't understand it, you're really going to be shooting yourself in the foot. So, I think for physics it's a big deal, not so much for chem though.

Theme 6: Active Learning and Argumentation Increased Self-Efficacy (Confidence) in AP Biology

The theme 'active learning and argumentation increased self-efficacy (confidence) in AP Biology' the participants described how they felt about using the metacognitive learning strategies in a science class. P2 expressed,

> I definitely think it had a positive impact. I think, uh, doing the case studies and arguing with other students is really helpful and in making sure you know what you are talking about. I think it established confidence because when you're arguing with someone else, you do have to really like, take a stand and so to get your point across clearly. So that definitely helped with confidence on the topic in general because you have better understanding of it overall.

P3 described the active learning and argumentation experience as overwhelming, exciting, and positive with a large breadth of content to learn. P3 recalled a lecture which occurred after a math exam,

> Yeah, it was like yeah. That was what I was going to elaborate on. Like it was exciting, but it was definitely overwhelming at times. It's like there's so much stuff and like we were and interested in like learning, but there so much like I remember at one point, like there was like 7 packets on the table. I just came back from a math test, and I was like oh man. But you actually let me relax for 5 minutes. I remember that.

Conversely, P3 articulated that the active learning hands-on experience increased confidence in AP Biology,

> Ok, so I'm going to speak on the labs because for the most part we did labs. Uh, it's definitely a confidence builder. Because when you are learning it, you have an idea, right? But the idea in your head you're not really sure about it. You're wondering if that's like legit what's actually supposed to be happening or like am I making this up. So, when you do a lab it's like not 50/50 anymore. It's like 100% that this is what it is about. And if you learned it right and it's right in your head the first time then by all means great. But if you did have a slight misunderstanding of the topic or didn't get it, with the labs you can alter what you know was wrong and what's right now.

Structural Description

Moustakas (1994) stated, "we imagine possible structures of the time, space, materiality, causality, and relationship to self and others" (p. 99). The imaginative variation stage of phenomenological reduction within this study allowed the researcher to obtain both participants' structural descriptions of the experience. Structural descriptions utilized the textural descriptions to describe the context or setting that influenced how the participants experienced the phenomenon. Imaginative variation described the essential structures that influenced participants to experience metacognitive teaching strategies in an AP biology course. P2 acknowledged active learning and argumentation increased comprehension as well as being beneficial to understanding scientific content.

Similarly, each participant described how the educator should facilitate the metacognitive learning strategies within the classroom for clarity and student engagement. This was how P2 described the experiences, “more effective in lecture because I think. … you as the teacher was able to monitor the conversation and like steer us into the correct direction with the case studies”. Thus, the P2’s rationale was “so if we were doing it by ourselves then students would get confused, it would be a little difficult to try to work out by ourselves”. P2 further elaborated on why educators should facilitate the metacognitive learning activities throughout the class period,

> But when you have someone who’s knowledgeable like the teacher to navigate you around a certain topic. I think that works much better and then you get to really experience it, but also have the added benefit of having some guidance.

Conversely, P2 expressed that active learning and argumentation may not be for everyone based on how their learning style. … “I mean, I guess it depends on the person. … but I guess somebody that learns better in different forms might not benefit from it”.

The facets of active learning and argumentation truly liked by P2 were involving real-life event case studies and argumentation. P2 felt it was a constructive way to assess whether a student understood scientific content from a “broad topic” to a “specific topic”. Similarly, P2 described that the case studies and argumentation were more effective in lecture because "we were definitely able to learn in a better way than just being taught the lesson and just listening. …It's one thing to listen to a teach speak and to just absorb."

Subsequently, the usage of case studies and argumentation required teamwork at times hence the P2's reflection on the experience with a team was straightforward on peer perceptions, acceptance, and expectations. P2's description of team assembly was "I think how it usually works one person will take the initiative and take the leadership" which depicted an understanding of how peers perceive leadership as being taking the initiative to solve a problem. Likewise, the group's acceptance of the roles after the leadership role was fulfilled

On the other hand, P2 described the ability to use for active learning and argumentation in other content areas as helpful to learning. For example, "so, yeah the method of active learning definitely translated to my other classes, so specifically in my English class" as well as " so, yeah, I definitely think, uhm math, I'm a very visual person. So, making diagrams of whatever we are learning definitely helped me." Moreover, when P2 described how and why the experience increased his/her self-efficacy, "I think it established confidence because when you're arguing with someone else, you have to really take a stand. …to get your point across clearly. …in general, because you have a better understanding of it overall."

Participant 3 (P3) voiced the metacognitive teaching strategies increased comprehension, however, he/she preferred active learning (hands-on) over argumentation as a way to understand and learn in science classes. Thus, P3 described his/her active learning experiences as "definitely beneficial to like the grasp concepts", however, he/she expressed, "but like I know for me the labs were fun because. …it was a fun activity then like oh wow, we just learned this like this cool! ... so, I like labs because it reinforced what we just learned in lecture." P3 had a vivid recollection of active learning laboratory which he/she engaged in the activity despite the noxious smell of the fake vomitus as well as remembering the unit topic, "we sat there working and laughing. We found out the victim's last meal based on the contents of the throw up. If I remember we were studying macromolecules?".

Conversely, P3 described his/her experience with argumentation as an intense process, "it was but you definitely capitalized on this method because. …you start interrogating us like, do you actually know what I'm talking about? ... you would like deep down drill in the concept." P3 continued to describe the case studies utilizing argumentation was viewed as homework assignments which considered not fun compared to laboratories, " I mean I guess you have to give homework like in every category, but like I know for me the labs were fun." Lastly, P3 expressed active learning enabled him/her to be a kinesthetic learner. "I like to learn, but I also like to get my hands dirty in what I just learned because I know in that way. … I have to study for the test less because I have an example. … I'll also understand it more."

Likewise, the participants illustrated how the educator should facilitate the metacognitive strategies within the classroom for clarity and student engagement. P3 felt that the inclusion of diagrams throughout the lecture and drawing them in their notes was beneficial because it requires a student to engage for understanding the diagrams, lesson, and notes, "you'd always have diagrams out, like it would be important to see what you're talking about. … we would have to draw diagrams in our notes that kept us listening because we needed to know what. … how it connected to the lesson".

Comparably, each participant explained that active learning and argumentation can increase learning but it is a student's learning and preference which promotes its usage in the classroom. For example, P3 stated, "so, I mean every kid learns differently. … like of course if you have like a 10 out 10 student and you give him a case study. …sure, he'll learn from it."

Then P3 articulated not only did it depend on learning style but he/she felt the case studies was an assessment for students who were struggling, "but case studies are kind of like for some students to like see what they know. Also, what they're like engaging more into and like what to focus more on." On the other hand, as the interviews continued P3 revisited his/her statement on case studies for certain students based on learning style. P3 expressed, " I feel like it's a good checkpoint. …you know you checkpoint for understanding and to know if everyone has got it. … then he/stated, " nobody understood chi square. …you were like ok I have to devote a one-day activity. …after class people left with a better understanding even if some of them still had question." Both participants articulated that they thought it was beneficial, fun, and exciting to learn science content through real-life events for specific content throughout the units. P3 recollected, "oh, I remember a lab we did on what is in nail polish. …looked at all the chemical structures for regular nail polish versus gel nail polish. …never knew like that many differences are because of a small change in structure until we built the models."

Next, the participants mutually described their experiences with interactive teaching and passive teaching in science classes. P3 expressed that his/her active learning interactive experience inspired a different "mindset" for increased understanding and comprehension. To further elaborate on his/her point P3 described that there was only one other class with the same format as AP Biology which was Engineering “we would learn code then the teacher would say oh now with what I taught you I want you to turn on the lightbulb. …he would have these labs to see what was working for you.” On the other hand, P3 described classes where the teacher speaks the entire period does not indicate the student was listening or even learning, “if you’re just looking at words and constant like talking like you’re hearing but you’re actually not listening. … so, the diagrams make you listen”. However, P3 felt that teaching strategies like active learning and argumentation could have limitations, ”the only one thing I can really think of is that those rare students who they like the boring lectures. …those are rare.”

Furthermore, P3 voiced his/her opinion and experiences utilizing active learning and argumentation which emphasized peer perceptions, acceptance, and expectations affects groupwork. P3 described differences between his/her lecture team versus laboratory team as well as how these experiences affected how the team worked. For example, “we had like an official lab group, but like one or two kids were like kind of not interested as me and the other kids, so it was taking away from the experience.” Conversely, P3 described how knowing each other has a common goal and understanding each other’s learning style as peers was conductive to active learning,

> So, like for the weekdays, we would have me, Daniel, Gilad, and Theo. …we understood each other and how we learned so we kind of understood how we should attack a problem to solve it. … you have understanding or awareness of is this kid compatible. …are they going to work together, or is this one going to sit down .... let the other one does all the work. … I think the group make up is very

> important who your teammates actually are?". Consequently, P3 conveyed that he/she had certain expectations of their team members, "one Friday, like somebody in my group whatever they're having a bad day. They were the who writes all the stuff down…ok, whatever I will write the stuff. … so, I figured by the second lab period, she'll feel better but then she affected the group to the point uh that some were just like whatever. … that was frustrating. … like I understand she was going through some stuff. … I forgave it.

Additionally, P3 continuously referred to active learning as an effectual method of learning whether in high school or post-secondary institutions which signified it was a transferable skill. P3's opinion was hands-on and real-life events gave a learning experience which passive instruction did not offer,

> When I was applying to college. … I wanted to see like what colleges offer that hands-on experience in the business field" then he/she stated, " the school I'm going to like a lot of professors and guest lecturers (volunteers). … they work in the city then come teach the students using real-life business examples. … I think that's really cool because again you're learning from someone who is actually doing it, not from someone who says I can teach you how to do.

In addition, P3 felt that active learning and argumentation was applicable in highly conceptual subjects, "I don't know so much chemistry . ... like it's more facts, you either get it or you don't, but physics it's a little bit between bio and chem. …there's a lot of concepts where you don't see actual examples".

In conclusion, P3 described his/her experience with active learning and argumentation as overwhelming, motivating, and a confidence builder with copious content to learn. P3 stated,

> "Like it was exciting, but definitely overwhelming at times….ok, so I'm going to speak on labs. … uh, it's definitely a confidence builder because. … you have an idea, right? … but the idea in your head you're not sure about. … so, when you do the lab. …it's a 100% that this is what it is about."

Composite Textural Description

At this study stage, both participants combined textural descriptions illustrated the differences and similarities between their perceptions and experiences, which speak to their distinct and individualistic nature of the phenomenon of learning with active learning and argumentation. Both participants in this study described their experiences with active learning and argumentation as beneficial to introductory biology classes.

When describing an awareness of active learning and argumentation as increasing comprehension, the participants articulated that the educator should facilitate strategies to increase student comprehension, engagement, and student learning styles. However, P3's experience with argumentation and case studies differed from P2's based on preference of learning styles. P3 described his/her experience with argumentation and case studies "we would answer confidently based on what we know but you would interrogate us at times." Also, P3 felt case studies were more like homework which were not as fun as laboratories, "I guess you have to have homework like in every category, but like I know for me the labs were fun".

Whereas P2 described argumentation and case studies, “I think the argumentation that we did was beneficial because I think that’s the best way to learn. … but the step of like really, truly understanding it is uh repeat it in your own words. … I would say it was exciting and it helped us really get involved in the topic.” Similarly, both participants expressed that the educator should facilitate strategies to increase student comprehension and engagement throughout the class period. Though, each differed on role and implementation, for example, P2 felt, “more effective in lecture because I think. …you as the teacher was able to monitor the conversation and like steer us into the correct direction with the case. …but also have the added benefit of having some guidance.” On the other hand, P3 described how instruction should include more than words and talking, “ lectures, uh you know you’d always have diagrams out, so. … would be important to see what you are talking about….we would have to draw diagrams in our notes….that kept us listening”.

Likewise, when describing student use of active learning and argumentation depended on learning styles for increased comprehension, each participant agreed that every student learns differently, which would affect their choices on whether to use both or one of the metacognitive learning strategies. But P3 further elaborated the case studies were a checkpoint of understanding for “certain students to see what they engage with and what they know” then he/she later on during the interviews he/she explained in reference to case studies,

> “So, towards the end like nobody understood chi square. … you were like oh, I have to devote a one-day activity. … I saw it as a good checkpoint because people

> didn't understand. … I think after class people left with a better understanding even if some still had questions".

When describing interactive teaching vs. passive teaching and effects on how students engage and learn in science classes the participants articulated teacher facilitating the lecture or laboratory, differentiated lessons based on student learning style, and delivery of lessons were an essential part. More specifically the participants wanted to experience lectures which did not contain only talking and listening. Also, P3 articulated that there were one other class which was similar to AP biology's learning format, "the only class I could think about that we had the same, uh structure of learning is engineering". Finally, each participant description aligned on how active learning and argumentation would not work for all students.

On the topic of how active learning and argumentation worked with team members, the participants had differing views on peer perceptions, acceptance, and expectations. P2's perspective was,

> I think how it usually works one person will take the initiative and take the leadership… .somebody's who's knowledgeable in something and then another person who's knowledgeable on something else. … it'll form like a group with uh like roles to solve the problem. … it was a group effort but each person like had their own role. …yes, we each choose an area that we felt confident in our understanding.

P2 believed there were differences between the weekday team and laboratory team which affected his/her experience, "we had like an official lab group. … I don't want to say names but like one or two kids were kind of not interested as me and the other kid, so it was taking away from the experience. … however, P3 described how his weekday teamed well together because their perceptions, acceptance, and expectations of each other,

> The weekdays, we would have me, Daniel, Gilad, and Theo. We all understood each other and how we learned so we kind of understood how we should attack the problem. …for at least high school it's really those groups that you make are important. …you have like an understanding or awareness of is this kid compatible with this kid. … are they going to work together or is this one going to sit down and let the other ones do all the work. … I think the group make up is very important like who your teammates actually are?

When exploring the details of their experiences with active learning and argumentation each participants described either how he/she used in another class or how it could be used, in another class however, P3 articulated the teaching strategies would be more effective in highly conceptual classes like physics. Next, P3's described how he/she purposefully looked for active learning in their post-secondary educational experience, "like when applying to college like I wanted to see like what colleges offered that hands-on experience and also like in the business field".

The last aspect of active learning and argumentation that the participants described was they had experienced an increase in their self-efficacy (confidence). P2's described his/her experience as,

> I definitely think it had a positive impact. … doing these case studies and arguing with other students is really helpful. … I think it established this confidence because when you're arguing . … you have to really take a stand so get your point

> across. …definitely helped with confidence in the topic in general you have a better understanding.

Similarly, P3 stated. “It’s a definite confidence builder. …because when you’re learning it , you have an idea, right? But the idea in your head you’re not really sure about it. …So, when you do the lab it’s not 50/50 anymore. It’s like 100% that this is what it is about. … with the labs you can alter what you know was wrong and what’s right now…”. On the other hand, P3 voiced, even “exciting” but “it was definitely overwhelming at times. It’s like there’s so much stuff and like we were interested in learning but there was so much”.

Composite Structural Description. The significant statements (horizons) and themes of both participants identified during the analysis process are utilized to write down a combined description of the context or setting that influenced how both participants experienced learning with metacognitive teaching strategies. The participants’ elucidated active learning and argumentation were beneficial to increase comprehension and understanding in learning sciences. Each participants’ description of the awareness of the strategies increasing their comprehension was cogent. The participants expressed their experiences in lecture and laboratory succinctly. P2 voiced

> more effective in lecture because I think. … you as the teacher was able to monitor the conversation and like steer us into the correct direction with the case studies”. Next, P3 vividly recalled a case study laboratory, “it smelled so bad. The lab with the fake vomit. … We found our victim’s last meal based on the contents of the throw up. If I remember we were studying macromolecules, right.

However, the participants diverged on their preference, P3 expressed this "definitely beneficial to like grasp the concepts but I know like for me the labs. …labs reinforced what we just learned in lecture." Additionally, P3 described argumentation as an intense process , "definitely capitalized on this method because. …you'd start interrogating us like, do you actually know what I'm talking about? ... you would like deep down drill in the concept". Whereas P2 described argumentation as "we were definitely able to learn in a better way than just being taught the lesson and just listening. …It's one thing to listen to a teach speak and to just absorb." Furthermore, P2 described argumentation "exciting" as well as "it helped us really get into the topic".

Furthermore, P3 described the case studies as homework assignments,

> I mean I guess you have to give homework. … but like I know for me the labs were fun." Then he/she expressed that case studies were comprehension checkpoints for certain students "but case studies are. … for some students to like see what they know. …what they're like engaging more into and like what to focus more on.

But later on, in the interview P3 described a class period where he/she observed case studies helped all learners,

> So, like towards the end like nobody really understood chi square. … you were like I have to devote a one-day activity where we did a bunch of math activities. …I saw that was a checkpoint because people didn't understand. …I think after class left with a better understanding.

Similarly, both participants cogitated the educator should facilitate the metacognitive strategies to increase student comprehension and engagement through monitoring discussions, guidance, and/or providing visual aids to enrich the lesson. For example, P2 expressed, “so if we were doing it by ourselves then students would get confused…but when you have someone who’s knowledgeable like the teacher to navigate you”. Similarly, P3 felt that incorporating visual aids (i.e., diagrams) increased student engagement in the lesson. For example, “you’d always have diagrams out, so like it would be important to see what you’re talking about. … to draw diagrams in our notes that us listening”. On the other hand, both participants intuited that active learning and argumentation usage depended on the learning style of the student. P2’s commentary was straightforward “I mean, I guess it depends on the person. …but I guess somebody that learns better in different forms might not benefit from it”.

Subsequently, each participants’ recalled experiences with active learning and argumentation involving real-life events which increased their interest in the topic as well as learning. P2 felt case studies (i.e., Tylenol case) and argumentation in lecture took “very broad topic” and the case studies were “very specific”. For example, “I thought that was very interesting and helped overall understanding of cellular respiration at the organelle level and what it does to the whole organism”. On the other hand, P3’s described the active learning case study laboratories with models,

> I remember a lab we did on what is in nail polish… chemical structures for regular nail polish versus gel nail polish. I never knew like that many differences are because of a small change in structure until we built the models.

Next, each participant voiced how the differentiated instruction affected learning in science. P2 articulated “It’s one thing to listen to a teacher speak and to just absorb” then he/she elaborated “it was exciting to have like a lively debate and be able to work amongst yourselves”. By the same token, P3 felt the same as P2 when describing if a teacher talks too much, “Because if you’re just looking at words and constant like talking like you’re hearing but you’re not actually listening”. Comparably, P3 imparted,

> Hands-on experience that just gets the cognitive like the mindset. … your brain is actively involved because like your hands were doing your eyes are observing like all your senses are involved in the assignment. So, like you’re getting a good grasp for the concept.

P3 further iterated that there was only one class similar to AP Biology’s learning format which was engineering “teacher would say. …with what I just taught you I want you to turn on the lightbulb. You have 10 minutes to turn on the lightbulb. … He would have these labs to like to see what’s working for you”.

When describing their experiences utilizing active learning and/or argumentation the participants described working within groups and working with team members. P2 describe how his/her group would form to a case study using argumentation, “how it usually works one will take the initiative and take leadership and then everybody else will kind of take their role” then “somebody’s who’s knowledgeable in something. …another person who’s knowledgeable on something else. …it’ll kind of form a group with roles to solve the problem. …we each choose an area that we felt confident in our understanding”. Then again, P3 experiences with peer perceptions, acceptance, and expectations differed between his/her weekday team vs. laboratory team. P3 felt that their experiences in laboratory were affected by the teammate’s behavior. For instance, P3 voiced,

> We had like an official lab group like. … but it was four. … but like one or two kids were like kind of not interested as me and the other kid, so it was taking away from the experience.

Subsequently, P3 conveyed,

> For the weekdays, we would have me, Daniel, Gilad, and Theo. We all understood each other and how we learned. …but like at least for high school it's really those groups that you make are very important. You have like an understanding or awareness of is this kid compatible with this kid like are they going to work together or is this one going to sit down and let the other one does all the work, you know?

Moreover, both participants described their ability to utilize active learning and argumentation in other contents areas as well as seeking these strategies at a post-secondary institution. P2 described how argumentation was utilized in his/her English, Global History, and Math,

> We had something called book trials where there was a pro and con side to a book. Our team had to read, annotate, and analyze a classic novel from any genre. …So, I then used the argumentation methods that we learned in your class to basically prove my point in English. …Uhm, math, I'm a visual person. So, making diagrams of whatever we were learning definitely helped. …but then in history it was used to produce timelines, you differentiate like at the same time period.

Nevertheless, P2 opinion was that active learning and argumentation "would be useful in chemistry". On the other hand, P3 articulated that active learning and/or argumentation usage is beneficial for

> But physics. … Like there's a lot of concepts where if you don't see actual examples, your kind of just going to be like oh ok, I guess. …As physics gets more complicated and you truly don't understand it, you're really going to be shooting yourself in the foot. So, I think for physics it's a big deal.

In conclusion, the final aspect that both participants described was active learning and argumentation increased their self-efficacy (confidence) in AP Biology. P2 expressed, "I definitely think it had a positive impact. …I think it established confidence. …definitely helped with confidence on the topic in general". On the other hand, P3 felt the active learning and argumentation, course load, and pace was "overwhelming" at times despite wanting to learn. Also, P3 described active learning (Hands-on),

> It's definitely a confidence builder. …so, when you do a lab it's like not 50/50 anymore. …it's like 100% that this is what it is about. …with the labs you can alter what you know was wrong and what's right now.

Essence

An inquiry of the student perceptions and experiences using active learning and argumentation metacognitive learning strategies revealed reflexive insight on whether it was constructive to their learning. In the analysis of the theme "awareness of active learning and argumentation increasing comprehension, " the participants explained it was beneficial, but P3 described it as overwhelming at times. Conversely, P3 preferred active learning laboratories because he/she described argumentation as an intense process. On the other hand, P2 described argumentation as a process that was exciting and engaging, which allowed an individual to put the content in their words to demonstrate understanding. In the subtheme "educator should facilitate strategies to increase student comprehension and engagement, " the participants described the teacher as a resource and guide during the lecture and laboratory.

Additionally, the educator should include visual aids in the lecture because they are hearing, seeing but not listening to the teacher, especially if the teacher is talking and/or giving notes that this does not provide clarity or engage students in science classes. In the subtheme ‘student use of active and argumentation depended on learning style for increased comprehension’, the participants described students learn in different ways, which affects their interaction with the metacognitive learning strategies. At the beginning of the interview process, P3 voiced case students were for those students who required a check for understanding as well as what engaged them during the class; then, as we proceeded, P3 reassessed his/her opinion on case studies because they were used when the majority of the class did not understand how to do chi-squares.

In the theme "active learning and argumentation utilizes real-events for understanding and comprehension," the participants described how using real-events case studies made learning science relatable to everyday life. Students building models illustrated how changes in structure affect structure and function on micro to a macro level. The theme "interactive teaching vs. passive teaching affects how students engage and learn in science classes" the participants cogently described their opinions and experiences in science classes where there is only chalk and talk. Both expressed that chalk and talk are not conducive to learning because the student is hearing, not listening, and not engaged after a while. P3 described in detail that there was one other class, an Engineering class similar to the AP Biology learning format. Additionally, P3 deduced that active learning and argumentation have a limitation. Thereby suggesting some students prefer chalk and talk to active learning and argumentation.

In the theme "peer perceptions, acceptance, and expectations in group work," the participants described different experiences and opinions. P2's experience was that whoever steps up first is the leader; everyone else follows suit into their roles based on their strengths. P3 articulated a difference between the weekday team and laboratory team experience, and the attitude and behavior exhibited by the other two members took away his/her laboratory experience. In contrast, the weekday team operated on a perceived understanding of each other's learning styles and how to work together to solve a problem. P3 articulated that it was crucial to know your teammates; for example, one should assess whether a peer is compatible and productive and understanding others before forming a group or team.

In the theme "transferable skills", the participants described active learning and argumentation as skills applicable in other content areas and post-secondary education. In the theme, "active learning and argumentation increased self-efficacy in AP biology," the participants expressed whether it was active learning and/or argumentation; their confidence increased because they could put content into their words and hands-on investigations cleared misconceptions.

Summary

The present study explored two students' perceptions and experiences about active learning and argumentation metacognitive learning strategies in introductory Biology. Two participants perceived active learning and argumentation as beneficial and a better way to understand scientific or highly conceptual content. Also, both participants described the metacognitive learning strategies requiring the teacher to facilitate the activities for clarity and engagement throughout the period, whether lecture or laboratory. However, both participants articulated that the metacognitive learning strategies are affected by the student's learning style. For instance, a student who prefers active, hands-on learning will not want to engage fully in a case study using argumentation. Lastly, P3 expressed he/her experience with argumentation as an intense process.

Subsequently, the participants described teaching using real-life events helped participants' comprehension because it was "relatable to everyday life," as well as the model building in the laboratory assisted with visualizing structures and how they affected structure. Next, the findings illustrated student experiences with science teaching that were not differentiated but, as P3 stated, "just constant talking," which was similar to P2's experiences. Nevertheless, the participants stated they felt active learning laboratories and/or argumentation were interactive and engaging, which increased understanding of the science topics. Conversely, one participant articulated there would be one limitation to active learning and argumentation usage, hence, a student who likes to listen.

The participants' demonstrated understanding of their peers' perceptions, acceptance, and expectations involving group work as seen depicted in the study's findings. Their experiences, although differing, never resulted in discord. The study's findings also revealed that the participants had used or would use the metacognitive learning strategies in another content (i.e., engineering, math, and/or English). Next, the participants described increased confidence using active learning and/or argumentation metacognitive learning strategies. In conclusion, Chapter 4 detailed an account of the study's results, including emergent themes and subthemes that stemmed from data analysis. Chapter 5 includes an overview of the study and an interpretation of the findings, in addition to a discussion of the limitations of the study, recommendations for future research, implications of social change, and my conclusions drawn from the study’s results.

Chapter 5: Discussion, Conclusions, and Recommendations

In this basic qualitative study, I used a transcendental approach to explore students' experiences with metacognitive teaching strategies and their perceptions about the value of these strategies for achieving conceptual changes and learning in high school introductory biology. Semi-structured in-depth interviews on students' opinions, perceptions, and experiences about and of metacognitive strategies establish themes, subthemes, and threads from the analysis. I associated these results through the framework of transcendental phenomenology to "examine the lived experiences of the phenomenon from the perceptions of those who experience them" (Giorgi, 1985 & Moustakas, 1994).

In Chapter 5, I present the interpretation of the findings through experiential and theoretical literature, limitations of the study, recommendations, implications, and conclusion.

Interpretation of the Findings

This section aims to present the results of this study to the experiential and theoretical literature researched in Chapter 2. Chapter 2 illustrated the experiential literature on metacognition, metacognition and conceptual change, active learning, and argumentation. In Chapter 2, I explained the theoretical framework for this study. Flavell's (1993) theoretical, experiential research on metacognition was the first framework to examine students' perceptions and experiences with metacognitive learning strategies in introductory biology courses. The second theoretical framework, Bandura's (1991, 1993, 1994) SCT of regulation and self-efficacy, examined the students' perceptions and experiences with the phenomenon. In the next section, the study's findings are first compared with the experiential literature than the theoretical literature.

Experiential Literature

The importance of metacognition in the process of learning is an old idea that can be traced from Socrates' questioning methods to Dewey's 20th-century stance that individuals learn more from reflecting on their experiences than from the actual experiences themselves (Tanner, 2012, p. 113). Current research typically refers to metacognition as an individual's thinking about their thought processes or cognitions about cognition as well as referring to knowledge, awareness, and control of learning processes (Flavell, 1999; Brown, 1987; Garner & Alexander, 1989; Thomas & Mc Robbie, 2001). Further research breaks metacognition into two additional aspects: self-appraisal and self-management (Cross & Paris, 1988; Paris & Jacobs, 1984; Paris & Winograd, 1996).

This study illustrated that through active learning and argumentation, the participants were aware of their learning processes and used classroom experiences for self-appraisal and self-management. For instance, P3 felt active learning allowed a student to clarify any misconceptions through laboratory related to the class lecture. Meaning that if he/she did not quite grasp the content, he/she understood the content or needed to go back and review the content/or their notes. On the other hand, P2 described that a student was aware of the learning process through argumentation, including the teacher is there for guidance and redirection.

On the whole, the themes that emerged from this study supported the current experiential literature related to metacognition and metacognitive learning strategies researched. Nevertheless, the majority of existing literature refers to (a) either active learning or argumentation research studies; (b) undergraduate introductory courses/populations, rather than high school science courses/populations; and (c) the majority of studies are on cognition in physics and chemistry. Only a few experiential sources specifically refer to cognition in biology, primarily studies on student perceptions and experiences with cognition and metacognitive learning strategies.

Hence, this study illustrated AP biology high school students, and this research extends the current literature. Likewise, it confirmed existing literature on metacognition and metacognitive learning strategies in the sciences. Both participants expressed their awareness of increased comprehension and understanding through utilizing the metacognitive learning strategies. Researchers posit that metacognition, sometimes referred to as "reflective thinking, has been seen as a means of critical higher-order thinking (i.e., cognition) to increase learning" (von der Linden, Loffler, & Schneider, 2015).

Flavell (1979) stated metacognition as three sections of metacognitive knowledge: person, task, and strategy (p.97). Knowledge of a person involves common knowledge about how the individual understands and processes information and personal knowledge of their learning processes. Knowledge of tasks includes understanding the nature of the assignment and the modes of processing exigencies that will affect the individuals. The knowledge of strategy component intermixes cognitive and metacognitive strategies and the individual discerning why she/he is learning the assigned task. Whereas Brown (1978) and Efklides (2006) differentiated between knowledge about cognition and regulation of cognition, which leads to metacognitive skills or use of strategies, and is in contrast to indicators of the control function. Because I explored students' perceptions and experiences with metacognitive learning strategies, this study confirmed Flavell's three sections of metacognitive knowledge but cannot confirm Brown's (1978) and Efklides (2006) statements.

Both participants demonstrated the three sections of metacognitive knowledge by stating they understood their learning styles and which strategy was effective for their comprehension. P2 felt argumentation allowed him/her to work amongst themselves with the teacher facilitating the discussion if he/she was off task or did not understand the task. On the other hand, P3 stated that active learning provided tangible examples connected to the content, which increased comprehension. Further, both participants stated that they liked how the metacognitive teaching strategies applied to real-life events. The metacognitive learning strategies' applicability to real-life answered their questions about why they received a particular task.

Metacognition or experiences occur before, during, and/or after a student begins a task or assignment. Flavell (1979) and Lories et al. (1998) suggested that metacognitive knowledge occurs within working memory through metacognitive experiences. The findings confirmed Flavell's (1979) and Lories et al., (1998) assertations. The results showed that P3's usage of study examples outside of class stemmed from recalling examples from the laboratory. On the other hand, P2 described how studying a real-life case clarified cellular respiration and how interactions with our environment can affect its ability to function correctly.

Learning and retention in science education in K–16 from public to private school settings are areas of concern. Researchers suggest that metacognition does have possible effects on conceptual change, learning, and instruction (Chauhan & Singh, 2014; Gunstone & Horthfield, 1994; Geoeghiades, 2000; Gunstone & Mitchell, 2005; Pintrich, 2002; Shaw et al., 2006; Tanner, 2012; White et al., 2011; Veenman, 2012). Based on both participants' perceptions and experiences, the study's findings confirm that metacognition can affect conceptual change in sciences, specifically Biology. For example, P3 recalled how chi-square was challenging to grasp; hence, I designed a metacognitive lesson plan to eliminate misconceptions and clarify its application. P3 recalled that it was good to revisit the topic because the students walked away with clarity on the topic and what they needed to know for the AP exam. Also, P2 expressed that case studies and argumentation broke down broad content into specific topic areas for better overall understanding and comprehension.

Comprehension in biology and the other sciences requires metacognition and conceptual change, which leads to critical thinking and problem-solving skills essential for the 21st-century workforce. Additionally, Lin's (2001) research on active learners depicted that these learners are aware of strengths and weaknesses and working towards fixing their weaknesses. In contrast, Lin & Lehman (1999) illustrated that students do not automatically engage in metacognitive thinking without explicitly stated directions for the assignment. Similarly, Brown (1992) showed that the design of learning environments is critical to developing cognitively and socially competent metacognitive learners. The study's findings confirmed Lin (2001), Lin & Lehman (1999), and Brown (1992) research. Both participants were in an AP Biology course with an interactive metacognitive student-based curriculum created using active learning and argumentation to increase learning and conceptual change. The curriculum included case studies, student-developed lessons, student feedback, teacher feedback, summative and formative assessments, and unit synthesis/application assignments.

Metacognitive teaching strategies are designed for students to develop habits of reflective study and critical thinking, thereby leading to learning and conceptual change. These strategies are inconsistently or rarely implemented in high school classes throughout the United States despite research studies illustrating its benefits for learning in the sciences (Ellis et al., 2012; Haidar & Al Naqabi, 2008; Kistner et al., 2010; National Research Council [NRC], 2007; Organization for Economic Co-operation and Development [OECD], 2003; Osborne & Dillon, 2007).

These study findings confirm that implementation is inconsistent by discovering through the interviews that there was only one other course utilizing metacognitive teaching strategies, and P3 stated it was an engineering course with a metacognitive curriculum similar to AP biology. Twenty-eight years of research studies demonstrate that metacognitive teaching methods increase conceptual change, learning, and understanding in K–16 students (Armbusher et. 2009; Corkin et al., 2017; Jensen et al., 2014; Kim et al., 2012; Linton et al., 2014; Sletten, 2017; Wilke, 2003).

Active learning promotes comprehension rather than rote memorization, which cultivates learning and independence, thereby giving students control over their learning (Armbruster et al., 2009; Bonwell & Eison, 1991, Freeman et al., 2014; Freeman et al., 2011; Gopalan, 2016; Nelson & Crow, 2014; Rutledge et al., 2015). *Active learning* involves activities that require higher-order thinking skills with varying levels of difficulty. These activities promote students constructing knowledge and understanding to learn. Subsequently, metacognitive activities will not at times overtly express to use of metacognition for task completion. Dale (1969) postulated that "learners retain more information by what they do as opposed to what they hear, read, or observed" (p. 108). The findings confirm active learning increased comprehension and understanding in Biology demonstrated through both participants' perceptions and experiences. P3 sought colleges and universities that had active learning integrated curricula because he/she felt that it is the best way to learning by doing then applying what you have learned. In contrast, P2 used active learning.

However, research has illustrated challenges to implementing active learning, such as educator inexperience (Bonwell & Eison, 1991; Creed, 1986), limited academic progress despite intervention (Sadeghi et al., 2014), educator resistance (Armbrusher et al., 2009; Evan & Leppmen, 1967; Miller & Metz, 2014), and student resistance (Finelle et al., 2018). The findings cannot disconfirm Sadeghi et al. (2014) and Armbrusher et al. (2009), Evan & Leppmen (1967), and Miller & Metz (2014) assertions.

However, the findings confirmed Bonwell & Eison's (1991) assertion as both participants voiced that educators should have content and practical knowledge to engage their students in the metacognitive learning process, even in post-secondary education. Correspondingly, the findings confirm Finell et al. (2018) assertion through both participants stating that metacognitive teaching strategies are not for students who want passive instruction. Lastly, current research depicted active learning used with metacognitive teaching strategies provide scaffolding in learning science content. For instance, argumentation combined with active leaving allows the students to clarify misconceptions through claims, reasoning, and justify their responses with scientific evidence.

Research on argumentation demonstrated positive effects on learning content knowledge (Zohar & Nemet, 2002) and conceptual change (Faize et al., 2018; Kaya et al.,(2012); Nussbaum & Sinatra, 2003; Sampson & Clark, 2009; von Aufschnaiter et al., 2008). Furthermore, current research identified that argumentation practices should be integrated into science education (AAAS, 1993; Acar & Patton, 2012; NRC, 1996, 2012; Sampson & Clark, 2009; Tsai, 2013). In the same way, argumentation promotes scientific literacy (Braaten & Windschitl, 2011; Cavagnetto, 2010, Driver et al., 2002; Sampson & Clark, 2011) and scientific practice supported by scientific concepts (Driver et al., 2000; Sadler, 2004), science processes, metacognitive processes (Mason & Santi, 1994), and deductive reasoning skills (McNeill & Pimentel, 2010).

The study's findings confirm the current research on argumentation effects on scientific content, literacy, and utilizing scientific evidence to support their claims in lecture or laboratory. For example, P2 described argumentation as a better way to learn because if she/he could put the content in their own words to support their claims, then he/she has truly comprehended the topic. Also, P2 used our argumentation format for English class book trials to present opposing viewpoints with evidence. On the other hand, P3 stated that argumentation was an intense process but was not averse to being a part of the process.

Research on argumentation described it as the language of science that allows students to understand scientific processes, increase communication skills, analyze scientific literature critically, and have higher-order thinking (Eskin & Berkirglu, 2008). Additionally, current research illustrated that language in the classroom develops through metacognition, social interaction, and deductive reasoning (Ford, 2008; Norris & Phillips, 2003; Vygotsky, 1978). Language is social interaction; hence, argumentation allows students to construct and communicate knowledge (Brown, 1990; Duschl, 2008). Based on the findings of this study, P2 expressed that he/she enjoyed the lively debate between the group because they invested in and engaged in learning the content. P2 voiced that he/she truly understood the topic if they could reiterate content knowledge in her own words to another student.

Unfortunately, despite current research highlighting the educational benefits of argumentation is under-used, not used, and/or improperly implemented in classrooms. In comparison, teacher certification and education programs have not included argumentation in preservice curricula (Boran & Bag, 2016; Driver et al., 2000) or integrated it into existing curricula for secondary sciences (Heng & Johari, 2013). These inconsistencies stem from multiple meanings in science education (Berland & McNeill, 2011). Current research on argumentation depicted its implementation from kindergarten through post-secondary education has used Toulmin's argumentation pattern model [TAP] or a modified version of his (Mason & Santi, 1994; Osborne et al., 2004; Sampson & Clark, 2008). However, I chose to utilize the Toulmin model currently utilized by other researchers (Kuhn & Reiser, 2005; Liotte et al., 2004; McNeill & Krajcik, 2007; Osborne et al., 2004). Also, for this study, an attempt to validate or refute a claim based on reasons that reflected the values of the scientific community defines argumentation (Norris et al., 2007).

An epistemic pursuit of the scientific community is scientific argumentation (Duschl, 2008) and quality that separates science from other areas of expertise. In addition, current research described scientific argumentation as a link between the scientific community and the science classroom. Thereby suggesting students engaging in discourse led to critical thinking skills, problem-solving methodology, innovation, and reflective practices (NGGS, 2012; NRC, 2012). Also, the goal of science literacy has been a global goal post-Sputnik creating a society of critical and reflective thinkers and innovators in science education reform (AAAS, 1993; NRC, 1996). The study's findings confirm that scientific argumentation increases dialogue, critical thinking skills, and reflective thinking in science classrooms. Both participants stated that argumentation increased their comprehension and understanding in AP Biology. However, P3 has preferred active learning because he/she felt it best suited their learning style and was less of an intense process.

On the other hand, P2 articulated it was the best way to learn a topic, including he/she enjoyed the diatribe between teammates and solving the problem. Also, he/she stated the relating the argumentation and case studies to real-life events increased interest, engagement, and learning of content. Lastly, the study's themes of transferable skills and peer perceptions, acceptance, and expectations in group work were inconsistent with the current literature; the findings extend and support the current literature on metacognitive and metacognitive teaching strategies value learning and conceptual change in learning biology.

Theoretical Literature

This study added to the existing body of research on Flavell's (1993) theoretical and empirical research on metacognition. Flavell (1979) further delineated metacognition as the three sections of metacognitive knowledge: person, task, and strategy (p. 907). Knowledge of a person involves common knowledge about how the individual understands and processes information and personal knowledge of their learning processes. Knowledge of tasks includes understanding the nature of the assignment and the modes of processing exigencies that will affect the individuals. The knowledge of strategy component intermixes cognitive and metacognitive strategies and the individual discerning why she/he is learning the assigned task. This study's exploration of participants' perceptions and experiences with active learning and argumentation in an introductory Biology course, thereby addressing and extending the current literature. Using Flavell's (1993) metacognition as a lens, this produced a detailed description of structural and textural experiences, which expressed an account of *what* the students experienced and *how* they experienced it.

The six themes that emerged from this study are (a) awareness that active learning and argumentation increases comprehension; (b) utilizing real-life events increased understanding and comprehension; (c) interactive teaching versus passive teaching affected student engagement and learning; (d) peer perceptions, acceptance, and expectations in group work was essential; (e) active learning and argumentation were transferable skills, and (f) active learning and argumentation increased self-efficacy (confidence) in AP biology. All six themes are consistent with Flavell’s metacognition research. Based on the results of the study, both participants implicitly employed metacognitive knowledge, experiences, and skills. For example, P2 utilized metacognitive knowledge of tasks during argumentation when he/she stated that each team members’ task was based on their strengths with regard to the current topic.

On the other hand, P3 illustrated metacognitive knowledge of tasks through their perceptions, acceptance, and expectations within his/her group, given that each member shared a common learning goal and understood each other's learning style to problem solve in class. Also, P2 employed knowledge of person through facilitating team members choosing areas that aligned to their learning styles (i.e., artistically inclined team member designed charts, tables, and layouts or detail-oriented team member transcribed the notes and laboratory data).

Similarly, P3 demonstrated knowledge of strategy components that intermixed cognitive and metacognitive strategies, as well as P3 discerning why she/he is learning the assigned task. For instance, P3 articulated after reteaching the chi-square unit then the class was clear as to why they needed to know this, how did it relate to AP biology, and what was required of them for the AP biology exam specifically. Further, both participants demonstrated self-appraisal and self-management through describing their experiences with active learning and argumentation. For example, P2 described how he/she knew she comprehended and understood a topic was the ability to put it in his/her own words.

On the other hand, P3 voiced that he/she knows after laboratory whether he/she completely understood the lecture or to readjust their understanding after practical application. Both participants illustrated self-management through articulating their learning style as well as which metacognitive teaching strategy promoted a better way for them to learn. Based on the findings of this study, both participants described feeling confident in AP biology after learning using metacognitive teaching strategies, which is vital to conceptual change, thus supporting Baldwin et al. (1999) and Bandura's (1991, 1993, 1994) social cognitive theory of self-regulation and self-efficacy.

Limitations of the Study

Potential weakness to a quantitative or qualitative research study demonstrates a limitation within the study's design that is not controlled. This study had several limitations. First, it was a limited time frame for both participants in that they had to be in the 11th and/or 12th grade during the school year 2019–2020. The study's second limitation was the methodological transcendental phenomenological approach potential for researcher bias. However, I engaged in epoche´ to eliminate bias towards the phenomenon and remove those biases during all stages of research.

Additionally, the researcher utilized reflective journaling and identified her biases outlined in Chapter 4. Third, the study was limited because it was at a private religious school, and the private school site could hinder generalizability. Fourth, the homogeneity of the participants could be another variable impeding generalizability. Lastly, the access to funding and resources at the private school could present limitations to generalizability.

Recommendations

This study was limited to a small number of former AP Biology students at a private religious school in a homogeneous learning environment which was a microcosm of the surrounding community during 2019–2020 school year in Long Island, New York. Future science education researchers could replicate this study at public and charter high schools that has a science curriculum integrated with metacognitive teaching strategies. Future studies could also explore students' perceptions and experiences in elementary and middle school science classes with metacognitive teaching strategies. The scope of this study as well as its emerging six themes illustrate further areas of future research.

Implications

Current research illustrated the effect of metacognition learning; despite this, limited research has concentrated on emotional components. The study's findings demonstrate the necessity for understanding students' perceptions and experiences with metacognitive teaching strategies then educators would know whether the strategies increased comprehension and understanding in their science courses. Thereby, suggesting knowledge of students' perceptions and experiences should create educators' awareness of what their students will engage with and respond to when writing curriculum to increase comprehension and understanding in the sciences. Further, your students' increased comprehension and understanding lead to increased self-efficacy in the sciences, affecting critical thinking and problem-solving skills, which are in demand in STEM or non-STEM fields. These skills lead to life-long learning and scientific literacy, which is essential for an evolving 21st-century society.

Additionally, "pedagogy is the activity of teaching, parenting, educating, or generally living with children, that requires constant practical acting in concrete situations and relations" (Van Manen, 2016, p. 2). As a result, it is similar to transcendental phenomenology, whereas they both are human sciences; hence it was an appropriate methodology to gain insight and understand students' experiences and perceptions in AP Biology utilizing metacognitive teaching strategies. The applicability of metacognition and its attributes was chosen as a theoretical foundation because it aims to develop critical and innovative thinkers.

For this reason, an educator should create metacognitive integrated scientific curricula which stimulate critical thinking whether inside or outside the proverbial box across content areas. Also, current research highlights students increased self-efficacy utilizing metacognitive activities, but limited studies highlight open-ended interviews to gain insight into their perceptions and experiences on how, why, and what about metacognitive teaching strategies increased their self-efficacy. This study demonstrated that their perceptions and experiences are invaluable to instruction and curriculum development.

Conclusion

> Its ability to create a truly just society, to sustain its economic vitality, and to remain secure in a world torn by hostilities-depends more than ever on the character and quality of the education that the nation provides for all its children.(AAAS,1989,1990, p. xiii)

The purpose of this basic qualitative study with a transcendental phenomenological approach was to explore students' perceptions and experiences with metacognitive learning strategies in introductory biology. This study the gap in the literature involving the perceptions and experiences of students' using metacognitive teaching strategies. The post-Sputnik education reform sparked an inquiry into our nation's education system from K to post-secondary levels, and its goal was to achieve an education system that produced critical thinkers and scientifically literate citizens. The present study tried to gain insight into the nuances and intricacies of AP Biology students' lived experiences and perceptions utilizing metacognitive teaching strategies. Both participants expressed their feelings and experiences as positive, intense, effective, and how their self-efficacy increased in AP biology.

In addition, through their perceptions and experiences emerged six themes associated with metacognitive teaching strategies. These themes illustrated that students (a) are aware of whether an activity or method will increase their comprehension and understanding; (b) want content and daily life relationships that are relevant to their learning process; (c) do not like passive teaching, especially in science areas where they feel unsure and/, or it is unfamiliar; (d) are aware of peer relations and acceptance in group work; (e) will employ these strategies in other content areas for comprehension, and (f) felt confident because they were allowed to make mistakes and/or correct misconceptions as a part of learning for comprehension and understanding.

This study's findings led to an increased understanding of the students' perceptions and experiences with metacognitive learning strategies. The described experiences demonstrated the inclusion of student voices in the discussion on science curriculum development. For example, P3 sought active learning at the post-secondary level because he/she believed learning content and practical business knowledge was the most accurate way to learn the business. On the other hand, the findings illustrated implicitly that I, as the educator am the cornerstone to effective implementation of metacognitive teaching strategies for student comprehension and understanding in biology.

In conclusion, Knowledge, Inquiry, Empathy, Pluralism, and Social Commitment are core values, which serve as the foundation of social change within this study. I propose to continue to seek knowledge, inspire inquiry across science content areas, create empathetic and pluralistic classrooms as well as advocate social commitment through science education. The paradigm shift in teaching methods proposed should promote and develop critical thinkers as well as STEM-skilled graduates to promote future economic national growth.

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Appendix A: Pilot Study Invitation

My name is [redacted], and I am a doctoral candidate in the Riley College of Education and Leadership at Walden University. You might already know the researcher as an AP Biology Instructor, but this study is separate from that role.

The study invites you to participate in a pilot study to validate a three-series interview protocol to conduct a primary research study exploring ***Student Perceptions about Metacognitive Learning Strategies in Introductory Biology.***

To be eligible to participate in this pilot study, you must be a former AP Biology student from 2017-2019. Your opinions and experiences are valuable to understanding the active learning and argumentation experience. This data can improve the interview protocol for the primary research study.

The information will be kept private and confidential. No organization or company will receive any private information. Furthermore, the research project is for academic purposes only.

Participation in this research is entirely voluntary, and you may choose to withdraw from the research at any time or not answer questions that you do not feel comfortable answering.

The adult participant informed consent included for your information. If you have any further questions about the research, please feel free to contact me via email at [redacted]. If you have any questions about your rights as a research participant, you can email [redacted]. The adult participant informed consent form is attached.

Thank you,

[redacted],
Principal Investigator Graduate Student
Walden University
[redacted]u

Appendix B: Primary Study Invitation

My name is [redacted], a doctoral candidate at the Riley College of Education and Leadership at Walden University. You might already know the researcher as an AP Biology Instructor, but this study is separate from that role.

The study invites you to participate in a research study to explore students' perceptions and experiences with active learning and argumentation in introductory Biology.

To be eligible to participate in this primary research study, you must be a former AP Biology student from 2019–2020. Your opinions and experiences are valuable to understanding the active learning and argumentation experience. The data collected to improve science instruction.

The information will be kept private and confidential. No identifiable information based on confidentiality will enter into a publication or presentation. I will not pass on any personal information to any organization or company. The research project is for academic purposes only.

Participation in this research is entirely voluntary, and you may choose to withdraw from the research at any time or not answer questions that you do not feel comfortable answering.

The adult participant informed consent form, minor participant parent, informed consent, and minor assent consent form attached for your information. If there are any further questions about the research, please feel free to contact me via email [redacted] If you have any questions about your rights as a research participant, you can call [redacted]. The adult/ minor parent participant informed, and minor assent consent forms are attached.

Thank you,

[redacted],
Principal Investigator Graduate Student
Walden University
[redacted]

Appendix C: The Three Interview Series Protocol

The interview questions focus on student perceptions about metacognitive teaching strategies implementation in biology. These questions are descriptive and narrative, therefore ideal questions for a qualitative study.

Introductory script: *Thank you for being a willing participant in this study. I want to remind you that I am doing this study as part of doctoral work at Walden University.*

Our interview process will be recorded with access limited to the researcher and the transcriptionist. A transcriptionist will create an official written version of our recorded interviews. All recordings are erased following the transcription process. Subsequently, all interviewees will receive a pseudonym for usage within my study. If at any time you decide you do not want to participate in this study anymore, it is entirely acceptable. There will be no penalty for withdrawing from participating in the study. Do you have any questions?

I am going to ask a series of questions about your experiences, perceptions, and feelings about the teaching strategies implemented. I am hoping that you will share your stories, thoughts, feelings, and perceptions that are relevant to the questions. You can choose the skip questions that you do not want to answer. Do you have any questions?

Interview One: Focused Life History.

1. Why did you register for AP Biology?
2. How does your family play a role in your academic planning?
3. Please describe how you feel about science in general?
4. How were your past experiences in your science classes compare between middle school and high school?
5. Please describe your feelings about learning new scientific material . Are you happy, sad, frustrated, excited, intrigued, nervous?

6. How do you plan and prepare for new courses in school especially your science classes?
7. Does your family support your scientific endeavors if you are involved in any during school or as an extra-curricular activity?

Interview Two: The Details of Experience.

1. How do you feel the metacognitive strategies improved your learning experience in AP Biology?
2. In what ways do you feel they were effective in lecture and laboratory?
3. Describe a class period for lecture or laboratory using active learning and/or argumentation.
4. How did you and your partner or teammates feel (i.e., excited, anxious, curious, overwhelmed) while engaging in the activities?
5. Do you think the activities increased team(s) ability to set learning goals to work towards a common goal?
6. What are your thoughts about how the activities increased your self-efficacy (confidence) in Biology?
7. Do you think the experience could be applicable in other areas of science for increased learning?

Interview Three: Reflection on the Meaning.

1. How did the metacognitive teaching strategies make sense in other areas of your life? If not explain your feelings.
2. How did you feel about the activities whether in lecture or laboratory?
3. Do you think there were any limitations to using these strategies? Explain your feelings.
4. How can this experience lead to best learning practices in other subject areas for you? If it cannot, please explain why you feel it would not or cannot affect best learning practices?

Adapted from Seidman, I.E. (3rd ed). (2006). *Interviewing as qualitative research*. New York: Teachers College Press.

Appendix D: Research Study Confidentiality Agreement

You have been hired to *[Insert task]* for *[Insert Researcher name(s)]*, on the research project *[Insert Title]*. The ethical guidelines of this study require that you read and sign this form, signifying that you are willing to enter into a confidentiality agreement with respect to the data collected in this study.

The audio recordings you will receive will likely contain identifying markers of the participants as well as names of third parties (for instance colleagues, family members and/or acquaintances of participants). To protect confidentiality, you are to remove all identifiers of third parties and of participants who wish to remain anonymous. If transcription occurs outside the university, you will ensure that all records, transcripts, and recordings are kept confidential (i.e., materials are never left unattended and are secured when not being used). By signing below, you agree not to reveal any information about what is contained on the audio recordings or in the written transcripts.

Furthermore, you agree not to discuss anything regarding the participants, or the data collected in this study with anyone other than the principal investigator.

By signing below, you are indicating that you have read and understand the above agreement and that you will follow the above specified conditions.

Name: ______________________________
Contact Telephone: ______________________________
Contact E-mail: ______________________________

Signature: ______________________________
Date: ______________________________

COVID-19 Procedure
Electronic* Signature
Date of consent ___________________________________

Electronic signatures are regulated by the Uniform Electronic Transactions Act. Legally, an "electronic signature" can be the person’s typed name, their email address, or any other identifying marker. An electronic signature is just as valid as a written signature if both parties have agreed to conduct the transaction electronically.

Appendix E: Transcendental Phenomenology: Stevick-Colaizzi-Keen Method

Transcript Participant 2

R: Thank You being a willing participant in this study. I want to remind you that I am doing this work as part of doctoral work at Walden university. Our interview process will be recorded with access limited to researcher and the transcriptionist. A transcriptionist will create an official written version of our recorded interviews. All recordings are erased following the transcription process. Subsequently all interviewees will receive a pseudonym for usage within my study. If at any time you decide you do not want to participate in this study. It is entirely acceptable. It will be no penalty for withdrawing from participating in the study. Do you have any questions? (paused)

R: Okey dokey, I'm going to ask a series of question about your experiences, perceptions, and feelings about the teaching strategies implemented. I am hoping that you will share stories, thoughts, feelings, and perceptions that are relevant to the questions. You can choose to skip questions that you do not want to answer. Do you have any questions? I know its redundant but there's research laws that must be followed for safety.

P2: Don't worry about it. Do what you gotta do (she laughs)

R: Ok, Thank You, Interview one focused life history. Why did you register for AP Biology?

P2: Well, I was interested in taking an advanced placement science class and I'm more attracted to biology than to the other sciences that involve more math like physics and chemistry.

R: That makes sense a logical choice considering you are not a science major. Ok, how does your family play a role in your academic planning?

P2: Uh, well my parents always pushed me to like to go into advanced classes and to work hard and do well in school and my older siblings have been role models and doing the same thing I was interested in that.

R: Do your siblings show you techniques on how to study in the various subjects since they're older and having gone through college and/or some type of work life experience?

P2: That's a good question. So, uh I guess the, the best method of studying would just to be to sit down and do the work like try not to procrastinate to work hard. But I think my brother kind of taught me flashcards is one of the best ways to study. I would say flashcards is 1 of the best ways to study.

R: Ok cool sounds good because you have identified how you organize for studying regardless of content. Ok next questions Please describe how you feel about science in general.

P2: I really like biology, but I'm not interested in like physics, and I'm really not interested in chemistry but biology I think it's very interesting.

R: and why do you find it interesting?

P2: Uh, just to like you know, how the human body works, how everything is developed, and how everything functions so well or sometimes when it doesn't function well, like to learn why that happens and how to correct it.

R: Please describe how were your past experiences in your science classes compare between middle school and high school.

P2: Well, obviously in high school the workload gets more difficult, and the material is more advanced. I took biology in 7th grade, 9th grade, and 11th grade and every year it starts to get like you get more depth of the information. So, it's definitely gotten more difficult, but it's also been more, more, work put into it, but more interesting and more applicable to like daily life. Ok

R: Please describe your feelings about learning new scientific material. Are you happy, sad, frustrated, excited, intrigued, and/or nervous?

P2: New science, science, natural or like biology or either one?

R: Any one it could be bio, but it could be any science. You've already said you're not into physics and or chemistry so use bio.

P2: Ok, so I'm definitely interested in learning new material and in science I think it's definitely very interesting and very important, too. Like our daily functions, it gets stressful with like tests, but if I'm just learning for the sake of learning, It's, it's , great.

R: So, it's safe to say your description would be one of happiness about learning new material.

P2: Yes!

R: Yeah, ok, how do you plan and prepare for new courses in school specifically your science classes?

P2: um, well before this the course will start, I'll get like a binder and make sure that I have all like the material that the teacher requests for each student to have and then if there is any summer homework or reading to do then I'll do that and any like necessary preparation. I'll do that.

R: Good and another question in that area, even if you're preparing summer homework, do you also utilize index cards? Or does that begin when the regular school year begins?

P2: Uhm, I would say the index cards are more for like tests more of like memorizing.

R: Uh-huh

P2: Perhaps so if there's no tests coming up, then no flash cards.

R: Ok, do you do any annotate any previous homework assignments?

P2: Yeah, yeah, I'll annotate like highlight, underline.

R: Ok last but not least. does your family support your scientific endeavors? if you are involved in any during school or as an extracurricular activity?

P2: My parents, my family would definitely approve of that if I were to see I mean if I do more as a class. but if I wanted to do like an extracurricular, then yeah, they definitely would be approving.

R: Do you have any questions because that concludes interview one.

P2: No

R: Ok, well I'd like to Thank you for participating in this interview. I will transcribe the interview and send it to you for member checking.

The Details of the Experience **- Interview 2 : Participant 2**

P2: Looking at the transcript from the interview, it's like I don't know if you like want to correct like mine are like little mistakes. In recording it like kind of sounds weird, but I know you have to like to do it exactly. So, like I don't know.

R: Yeah, if there if it's not what it's supposed to be yes, you correct it.

P2: Ok if it's like grammatical.

R: Oh, no you do not have to correct for grammar. If I missed something or it's been misquoted, then you can correct but they are not checking for grammar. Ok, so this is interview 2 and this is called the details of the experience. So, let's get this going! How do you feel about metacognitive teaching strategies which were active learning and scientific argumentation improve your learning experience in AP Bio and can you give an example?

P2: Can you give an example ?

R: For example, active learning was the case studies then we built models on the other hand scientific argumentation was would you were required to explain and justify your reasoning.

P2: So, right I think the argumentation that we did was beneficial because I think that's the best way to learn to know if you have fully understood a topic. It's one thing to listen to a teacher speak and to just absorb, but the next step of like really, truly understanding it is to uhm repeat it in your own words and really try to like work your way around the entire topic and figure out for yourselves like what's what.

R: I agree but I shouldn't say I agree because I don't want you to think I'm forcing your opinion, but I should say I understand what you meant. What ways do you feel they were effective in lecture and laboratory?

P2: I'm not sure I understand the question.

R: So basically, how do you feel the case studies, modeling, and/or role playing of the concepts worked in lecture versus laboratory. Do you think they were effective in both, and were they more effective in one area than the other?

P2: I think they were more effective in the lecture because I think, uh, that you as the teacher was able to monitor the conversation and like steer us into the correct direction with the case studies so if we are doing it by ourselves then students would get confused, it would be little difficult to try to like to work it out by ourselves. But when you have someone who's knowledgeable like the teacher to like to navigate you around us around a certain topic. I think that works much better and then you get to really experience it, but also have the added benefit of having some guidance.

R: Ok, so in laboratory did you feel at times argumentation was effective in laboratory?

P2: Uh, yeah definitely.

R: Definitely ok describe a class period or lecture or laboratory using active learning and/or argumentation.

P2: So, one of the case studies that I remember most ok we did a kind of group argumentation on the spiked Tylenol capsules, and it worked in the body. You had to kind of figure out what went wrong. The medication and how it affects this like large diverse group of people. And we figured out it was the Tylenol that was contaminated. Ok, that's a good example. I don't know if that's answering your question.

R: Well, when you say you realized that a large group was contaminated, how did you find out the group was contaminated? What was the overall aspect of finding out how the group was contaminated?

P2: So, uh if I remember correctly, the lab stated that like a whole bunch of different people were having these symptoms having similar symptoms, but they weren't like they didn't live in the same environment, they didn't have similar genetics that meant the only constant between the group was the Tylenol. We were able to figure it out looking at the people's symptoms then we knew what contaminated the Tylenol and caused sickness and death. They were poisoned with cyanide and that affects the mitochondria.

R: How did you and your partners feel while engaging in the activities?

P2: I think, me and my classmates benefitted from this experience. I think we definitely were able to learn in a better way than just being taught the lesson and just listening. I think the active debate was beneficial to the overall comprehension of the topics.

R: So, you would say you were excited, anxious, or curious or overwhelmed by the topic?

P2: I think I think it was exciting to have like a lively debate and to able to work it amongst yourselves. I would say it was exciting and it helped us really get involved in the topic.

R: Ok, do you think the activities increased the team's ability to set learning goals to work towards a common goal?

P2: Yes, I think so.

R: And how did they? How did you go about setting those goals? Was there one specific person or was it a group effort?

P2: I think how it's usually one person will take the initiative and take the leadership and then everybody else will kind of take their role as like debating a certain topic or somebody who's knowledgeable in something and then another person who's knowledgeable on something else. And then it'll kind form like a group with uh like roles.

R: So, each one?

P2: So, it was a group effort but each person like had their own role.

R: Expertise, right? So, I got it. So, in essence, what you're saying, even though it was the broad concept of understanding how Tylenol could affect five different people in the several areas and why they all had the same symptoms hence each person picked a specific area under the topic.

P2: Yes, we each choose an area that we felt confident in our understanding.

R: Ok I understand that completely. Oh, this is the next one. What are your thoughts about the activities increased your self-efficacy? Confidence in biology?

P2: I definitely think it had a positive impact. I think, uh, doing these case studies and arguing with other students is really helpful and just making sure I think it established this confidence because when you're arguing with somebody else, you have to really like, take a stand and so to get your message across clearly. So, that definitely helped with confidence in the topic in general cause you have better understanding of it overall.

R: Ok and here's our last one. Do you think the experience could be applicable in other areas of science for increased learning?

P2: in other areas of science? I don't really understand.

R: Like for example, and we know you don't like these subjects. Would you think it would be useful in let's say chemistry?

P2: I think it would be useful in chemistry because like similar to the case study with Tylenol. I guess like if something went wrong with like the chemical makeup of like a drug then you can figure it out. Why that happened and how to fix it?

R: I understand what you are saying about how within chemistry you could use active learning and argumentation. I'm going to end here. I feel went rather well not bad at all. I have to Thank You once again for participating in my study. I will transcribe the interview and send it to you again for member checking.

P2: Ok, I will look out for it because I have an AP and a final coming up.

R: Good Luck and it you have to study then do that first, ok.

P2: Yes, I know. Take care.

R: Take care.

Reflection on the Meaning **- Interview 3: Participant 2**

R: Welcome back! Thank you for member checking the last interview. I'm going to ask a series of question about your experiences, perceptions, and feelings about the teaching strategies implemented. I am hoping that you will share stories, thoughts, feelings, and perceptions that are relevant to the questions. You can choose to skip questions that you do not want to answer. Do you have any questions? I know its redundant but there's research laws that must be followed for safety.

R: Let's go. Reflection on the Meaning: Interview 3 question, how did the metacognitive teaching strategies we already talked about i.e., active learning and argumentation make sense in other areas of your life in school? And if not explain your feelings.

P2: Can you explain what you mean by life?

R: So, I guess what that would or could mean is did you use it in other areas, for example in your other classes? For example, like in AP psychology did you use case studies/argumentation or in history class, and/or did you use the concept index cards/models? Even though I'm looking at biology, it was it could have been applicable in other areas.

P2: So, are we talking like the debating with the case studies?

R: Yeah, so case studies could have been used in other areas or models or concept index cards could have been used in other areas. Or even how we tried to make a set standard/learning goal of how we wanted to think and study in order to pass the exam and use it beyond the exam.

P2: Ok, so yeah, the method of active learning definitely translated to my other classes, so specially in my English class we had something called book trials where there was a pro and con side to a book. Our team had to read, annotate, and analyze a classic novel from any genre. Basically, we said that a book that we were reading was not appropriate for private schools. So, I then used the argumentation methods that we learned in your class to basically prove my point in English. Also, it translated to debates that we would have in history class. Did that answer your question?

R: Yes, you did, and you gave me examples, so that's good, too. Because I know you're not a science major. How did you feel about the activities, whether in lecture or lab?

P2: So, uhm, I really like how we would learn. We would learn a very broad topic and then we would in the case studies become very specific. I really like how it was applicable to everyday life. So, with the case studies especially the Tylenol one where we had to learn what the symptoms meant and what went wrong. I thought that was very interesting and helped overall understanding of cellular respiration at the organelle level and what it does to the whole organism. Then definitely breaking up into groups and debating and having to defend my position was helpful in learning.

R: Ok, moving on. How can this experience lead to best learning practices in other subject area? Like did you in the way you studied, did formulate arguments, and then look for backup information? Were you able to make models for let's say math or construct diagrams for history?

P2: Right, so yeah, I definitely think, uhm math, I'm a very visual person. So, making diagrams of whatever we were learning definitely helped especially you could see it written out but then in history it was used to produce timelines for a series of events which was helpful. For example, if it's like global history, you differentiate like at the same time period what was happening in Europe and in America.

R: Ok so cool you make a chart, or a table like with countries then build your visual model of comparison?

P2: yes, exactly.
R: Please explain why you feel it would not or cannot affect best practices.
P2: I mean, I guess it depends on the person. For me, I don't think it would. I don't think it has ever negatively impacted me, but I guess somebody that learns better in different forms might not benefit from it. Actually, yeah, personally it was very beneficial to me.
R: Well that concludes our interviews. I would like to Thank You for time and I will be sending the transcript for member checking.
P2: Ok no problem.

Appendix J: Transcendental Phenomenology: Stevick-Colaizzi-Keen Method
Transcript Participant 3

Focused Life History - Interview 1: Participant 3

R: Thank You being a willing participant in this study. I want to remind you that I am doing this work as part of doctoral work at Walden university. Our interview process will be recorded with access limited to researcher and the transcriptionist. A transcriptionist will create an official written version of our recorded interviews. All recordings are erased following the transcription process. Subsequently all interviewees will receive a pseudonym for usage within my study. If at any time you decide you do not want to participate in this study. It is entirely acceptable. It will be no penalty for withdrawing from participating in the study. Do you have any questions?

R: Okey dokey, I'm going to ask a series of question about your experiences, perceptions, and 7feelings about the teaching strategies implemented. I am hoping that you will share stories, thoughts, feelings, and perceptions that are relevant to the questions. You can choose to skip questions that you do not want to answer. Do you have any questions?

P3: No, I do not have any questions.

R: Good, interview one focused life history. Why did you register for AP Bio?

P3: Uh, ok, uh first I needed a more rigorous course load because mid, 11th grade I needed to like step up my game. I needed to like to be marketable to the colleges. So, I needed an AP. I was good at Bio I freshman year. So, I said oh probably I'll be good at AP Bio junior year. So, yeah, I thought that was a nice power move, so I took AP Bio.

R: Ok, so that was a power move. Would you like to expand on why you thought it was a power move?

P3: Uhm, ok so I knew the college I wanted to get into is like highly selective and I needed to like stand out. So, I kind of was going for like this uh, perception of like, I could take a bunch of like rigorous classes, hard classes and just breeze through them. So, like you know, so I like to stand out more.

R: How does your family play a role in your academic planning?

P3: Uh, not so much. I've really been independent, but they've always offered me like tutoring. They are just I just always thought, like, I got it by myself like it's fun.

R: It's good, so you mentioned tutoring like do they help you in choosing courses or anything like that?

P3: Uh, not really.

R: They leave that strictly to you and support you in whatever your choices are? Ok please describe how you feel about science in general.

P3: uhm, science is very interesting. I feel like a lot like it's basically a hit or a miss like either you love it or kind of interesting or you find it like boring and it's like facts being thrown at you but it's like different in your class. There's I feel like I'm towards the interesting side cause like at the same time as, you're learning but it's also like you know, in like some classes you can like think critically, you know, think outside the box. Kind of like could be interesting sometimes.

R: So, you like it, so it seems like you like a challenge.

P3: Yeah, yeah!

R: How were your past experiences in science classes, for example, compare middle school and high school?

P3: So middle school there were assignments due once every two weeks. You know it was very little and it was like a 30-minute period you know. Oh, actually that was elementary school and middle school we had a science teacher, but it was like every other week. We didn't have it every week and like whatever she would explain, you know some basic science stuff we would like go outside and like check the temperature and stuff like. Yeah, science in middle school was tough because teacher was really harsh. She was hard like she was a tough cookie. So, I think like that was like my first perception of science, so it was kind of like, not the best. Like you know, not the best introduction to science. In fact, teacher was very tough.

But I always thought it was interesting.

R: All now you did elementary and middle school. How about high school?

P3: High school yeah, I would say it was interesting, but I was more focused on like getting that just getting the A. You know, like I didn't think that I would be like looking to have any major that requires like science in the future. So, like I wasn't as interested but I think I was more open to middle school.

R: Please describe your feelings about learning new scientific material. Are you happy, sad, frustrated, excited, anxious, and/or nervous?

P3: Uh, I think it's very, uh, it's different. So compared to like a history class like in history. Basically, like everything is set in stone, all stuff has happened and like we were just learning what has happened but in science, like you know, like we were learning new stuff. Every day and like it's like people know that stuff happened and it's still happening in science. It's evolving everyday not like history. But in science, like you know, like we're learning new stuff. It's different and it's interesting, it's a unique type of learning.

R: Oh, I understand what you're saying science is unique because it's evolving.

P3: Yeah, yes.

R: Ok how do you plan or prepare for new courses in school, especially your science classes?

P3: So, like in high school, how do I prepare? I would like listen, understand what's actually going on, and then write it down because I want to like get, grasp the idea in my head before I just like to write down, but you know 40-minute periods like one of my classes where I just sit down and focus. Because like I don't know well for a lot of other classes, I feel like I don't really need the teacher as much and I can kind of teach myself. I feel like math and science aren't one of those like they can get tough, so I just focus the whole period because I don't want to teach myself later.

R: So, basically, you're focusing while you're in the lecture in order to understand the concepts. Yeah, ok, and then after that you go home, do you have another plan of attack for that? Do you for example, better yet can you give one example of after you've had a lesson, and you were like OK I got it but now I have to put together once I get home. How do deal with that?

P3: I mean not only at home like we would do labs and like you would actually do like a 10- minute task also then I would understand like oh, this is what I'm actually doing , what I am learning. Sometimes when I'm reviewing, I could actually think like, oh, what's like a real-life example of this, you know like I could now remember the activity from lecture but while in lecture it’s all going so fast but I’m sure I grasp and remember the concepts more after the activity whether case studies or argumentation.

R: Gotcha, ok last question, does your family support your scientific endeavors? If you involved in any during school or as an extracurricular activity?

P3: I mean I haven’t participated because I’m a nonscience major.

R: Ok, so is there anything else you would like to elaborate on?

P3: uhm, no I got nothing else.

R: Thank You for participating in my study. I will transcribe the interview and send it you for member checking.

***The Details of the Experience* - Interview 2 : Participant 3**

R: I want to thank for member checking the transcript for interview 1. Ok so this is interview 2 and this is called the details of the experience. So, let's get this going! How do you feel about metacognitive teaching strategies which were active learning and scientific argumentation improve your learning experience in AP Bio? Let me explain what I mean by metacognitive teaching strategies. Our work case studies, laboratories, models, and projects, ok, argumentation was anytime I asked you to explain and justify your reasonings, whether it was against another team or within a case study or as a homework using scientific knowledge.

P3: Yeah, so for the most part it's definitely beneficial to like grasp concepts but I have to say (paused) like it's that everybody learns in a different way. You know, like I know some people, they get it more when they're doing a lab cause like it's like they're engaged. Because it's also fun. There's the fun aspect, so now they like they want to learn and then the case studies like UGH I know a lot of people like oh they view it as homework. so, they try like to get through it. So, I mean every kid different, like of course if you have like a 10 out of 10 student and you give him a case study. I'm sure he'll learn from it. But the case studies are kind of like for the students and to see like what they know. Also, what they're like engaging more into and like what to focus more on? I mean, I guess you have to give homework like in every category, but like I know for me the labs were fun because like I saw it as a fun activity then like also like oh wow, we just learned this like this is Cool! So, like I like labs because it reinforced what we just learned in lecture. And you know actively think while doing them, so I think labs over case studies. But you know, homework must be given. So, like you know, you don't lose what you learned.

R: In class ok I want to piggyback on what you just said when you said in the lab. It was like you said you were actively learning. You understood the difference between the laboratory versus the case studies. So, can you explain what was the difference? What was specifically did it mean to you to actively learn right after the lecture content?

P3: So basically, for me at least, I'm a very hands-on learner. Like when I was applying to college like I wanted to see like what colleges offer that hands-on experience and also like in the business field. One of the main schools that is notorious for doing that is Michigan Ross. And like I thought that was very important for me because like I like to learn, but I also like to get my hands dirty in what I just learned because I know in that way. Like first of all I have to study for the test less because I have an example to go and I'll also understand it more, you know.

R: Tell me about a typical lab day.

P3: Ok, there was a lab, but I only remember it so vividly because it smelled so bad. The lab with the fake vomit. We were trying to see what foods were digested. Oh, it smelled so bad and the color, Ms. Collier! (laughing)

R: Yes, I remember because I thought some of the kids were going to vomit and I was like I hope they don't vomit at the same time but then I said y'all held it together like true scientists.

P3: Yeah, we held together. And everybody was like engaged. It was also like funny, so like nobody was like, oh we don't want to do this. We sat there working and laughing. We found our victim's last meal based on the contents of the vomit. If I remember we were studying macromolecules, right?

R: Yes, that's right ! Ok, and you touched upon this, but I'm going to still ask the question. In what ways do you feel they were effective in lecture and laboratory?

P3: Im sorry you cut out for second. What was did you say?

R: Ok, no problem. In what ways do you feel they were effective in lecture and laboratory?

P3: So, lectures, uh, you know, you'd always have diagrams out, so like it would be important to see what you're talking about. Because if you're just looking at words and constant like talking like you're hearing but you're not actually listening. So, the diagrams actually make you listen, you know. And we would have to draw diagrams in our notes that kept us listening because we needed to know what was going in the diagrams and how it connected to the lesson. Oh, I remember a lab we did on a lab on what is in nail polish. We looked all the chemical structures for regular nail polish versus gel nail polish. I never knew like many differences are because of a small change in structure until we built the models. Oh, that was similar to the other lab where we built models for all the levels of a protein. So, it was helpful to see what you are talking about and like building it helped me to understand like you said hundred times structure and function.

R: I like that because usually people your age doesn't differentiate between hearing and listening.

P3: It's a big difference. And for labs I feel like yeah, just hands-on experience that just gets the cognitive like the mindset like your just your brain is actively involved because like your hands were doing your eyes are observing like all your senses are involved in the assignment. So, like you're getting a good grasp for the concept.

R: Ok, one more thing I would like to you to talk about. We didn't speak about argumentation so how was argumentation effective in lecture and laboratory? And I'll give you an example. For example, if we just finished something and gave you a question. And I asked you, you know, out you in a group. Was that effective in learning the concept? The ability to explain and justify your reasoning using scientific evidence?

P3: I mean yeah, it was but you definitely capitalize on this method because you would say it in a way like as if, like you would question us like you would start interrogating us like, do you actually know what I'm talking about? Or are you just saying you know? You know like you would like deep down drill in the concept and be like don't give me no shenanigans! Do you understand it? We would answer correctly based on what we were doing, and you would say are you sure? Are you sure? we would answer confidently based on what we know but you would interrogate us at times. A lot I should say (laughing).

R: It was out of love (laughing)

P3: For sure, for sure ! (laughing)

R: I just wanted to make sure that you knew the content because some kids will yeah, yeah, you and not know a thing you just said in class. I tell you all the time my idol and you are not supposed to idolize but Albert Einstein said If you can explain it in the simplest of terms anything that means you know it. You should be able to tell your bubbe and she should be able to understand it.

R: Ok let's move on. How did you and your partner or teammates feel while engaging in the activities? Excited, anxious, curious, overwhelmed?

P3: I mean like what kind of activity? in the lab?

R: Either or whether it was the case studies, the laboratories, or where I had you write a T-chart. The diagrams you know because a lot of things were being thrown.

P3: Yeah, it was like yeah. That was what I was gonna elaborate on. Like it was exciting, but it was definitely overwhelming at times. It's like there's so much stuff and like we were and interested in like learning, but there so much like I remember at one point, like there was like 7 packets on the table. I just came back from a math test, and I was like oh man. But you actually let me relax for 5 minutes. I remember that.

R: I remember that today too. Mr. Nagel and I was killing it on the academic rigor. But seriously I am figuring both of us were trying to give you skills to utilize after high school. You won't realize until later at the next level. (laughing) Ok, moving on. Do you think the activities increased your team or teammates, ability to set learning goals to work towards a common goal?

P3: Uhm, ok, I think I understand the question. Are you saying like, uhm, like because we're in a group environment? We want to learn more, is that like what?

R: Yeah, like for example, when it came to whether you met outside of class or in class, and you're doing a case study, did you set goals to get the job done? In that area, or if it was a laboratory group, the did you work within your group to set a common goal? And how did you go about setting those common goals then the idea of active learning and argumentation? How did you organize yourself as a group to meet the common goal?

P3: Right, so uhm, we had like an official lab group like, oh I don't remember who it was, but it was four and I remember like I don't wanna say any names but like one or two kids were like kind of not interested as me and the other kid, so it was taking away from the experience. But, like, uh that was only on Friday, so like for the weekdays, we would have me, Daniel, Gilad, and Theo. We all understood each other and how we learned so we kind of understood how we should attack the problem. So, I feel like obviously when you go to college like you're not going to know as many people but like at least for high school it's really those groups that you make are very important. You have like an understanding or awareness of is this kid compatible with this kid like are they going to work together or is this one going to sit down and let the other one does all the work, you know? I think the group make up is very important like who your teammates actually are?

R: That's a good one as how you said it's about how the group works together towards successfully completing the task or lab can depend upon having a common understanding or familiarity amongst your peers. Can you give a specific example in laboratory when the team did not work towards a common goal?

R: You do not have to mention names.

P3: Ok so yes, running with one Friday, like somebody in my group whatever they're having a bad day. They were the person who writes all the stuff down. So, like ok, whatever I will write the stuff down for lab. So, I figured by the second lab period, it was like stupid but whatever she'll feel better but then she kind of affected the group to the point uh that some were like whatever let's just be out of it. She was like whatever since I'm not, let's just all be out. So, like I remember that was one time that was frustrating, but it was like was fine. Like I understand she was going through some stuff. So, it's like I forgave it. Like forget it but that was one time yeah.

R: So, you forgave her and forgot it. (laughing) What are your thoughts about how the activities increased your self-efficacy which is confidence in Biology?

P3: Ok, so I'm going to speak on the labs because for the most part we did labs. Uh, it's definitely a confidence builder. Because when you are learning it, you have an idea, right? But the idea in your head you're not really sure about it. You're wondering if that's like legit what's actually supposed to be happening or like am I making this up. So, when you do a lab it's like not 50/50 anymore. It's like 100% that this is what it is about. And if you learned it right and it's right in your head the first time then by all means great. But if you did have a slight misunderstanding of the topic or didn't get it, with the labs you can alter what you know was wrong and what's right now.

R: Do you think the experience could be applicable in the other areas of science for increased learning?

P3: Uh, can you elaborate on that ?

R: Like for example, since I'm just looking at science , do you think it would be effective in chemistry? Do you think it would be effective in general Biology? Do you think it would be effective in physics?

P3: Yeah, definitely. I don't know so much chemistry because it is what it is in chemistry. It is what is at that point. Like it's more facts, you either get it or you don't, but physics it's a little bit between bio and chem. Like there's a lot of concepts where if you don't see actual examples, your kind of just going to be like oh ok, I guess. But that's OK, I guess mentality, yeah? As physics gets more complicated and you truly don't understand it, you're really going to be shooting yourself in the foot. So, I think for physics it's a big deal, not so much for chem though.

R: So that ends interview two and now I am going to begin interview three which is the reflection of meaning.

Reflection on the Meaning **- Interview 3 : Participant 3**

R: How did the metacognitive teaching strategies make sense in other areas of your life? If not explain your feelings. What I mean by this is did you use argumentation, for example, like in history, math, where you had to justify and explain your reasoning? Did you experience active learning like case studies, diagrams, models, and so forth? Also, what I mean in other areas in life, and did that type of thinking carry over into how you regulate yourself outside of class?

P3: I mean really the only class I could think about that we had the same, uh, like structure of learning is engineering like, I really can't think of any other class because engineering it's very conceptual. What I mean there are different ways to understanding something in engineering so basically, we would learn to code then the teacher would say "oh, now with what I just taught you I want you to turn on the lightbulb. You have 10 minutes to turn on the lightbulb by plugging it into your computer and turning it on then make it flash two times." So, at the end like nobody had the identical code like that's near impossible. So, like we would have these like I could them lab. He would have these labs to like see what's working for you like it didn't matter what the next person was doing but it was like what is working for you in class.

R: Ok, how did you feel about activities whether in lab or lecture?

P3: I feel like it's a good checkpoint. You know you checkpoint for understanding and to know if everyone has got it then ok, let's move on.

R: All right, just give me one example.

P3: Uh, so like towards the end like nobody really understood chi square so you were like ok, I have to devote a one-day activity where we did a bunch of math activities but you made it fun. I like kind of understood because of previous math classes so like kind of like observed the class. And uh, it was one of the more complex topics in Biology, so people tend to be like not understand it as much as like other things. So, like people, I could see were like making tricks to learn it. Like, uh they were like ok what do I have to do like to understand this because I'm clearly not getting it and this confusing so like what tricks can I make to know this and remember this. So, like you know I saw that was a good checkpoint because people didn't understand it and I think after class people left with a better understanding even if some of them still had questions. But I think they had a good idea of like what to do on the test.

R: Oh, great Im glad it made sense in relation to the AP. Next, do you think there are any limitations to using these strategies? Explain your feelings.

P3: Limitations, hmm I mean, the only one I can really think of is that those rare students who they like the boring lectures and like they can just sit down like I guess it's taking away from them. But then again, those are like rare. I don't come across many of them but straight robots who can like sit down and listen to words.

R: Three hours and just sit there, right? I am not laughing at but I will say this to you I have experienced that situation with that type of student for the first time in my career this year. It was quite different. They wanted lecture and nothing else could not see the value in anything then lecture and test prep and they were like I'm good with that.

P3: Yeah, it is rare, but when it happens it's like whoa. It's impressive, you know like I feel they were reading books from a very young age, so their attention is like much stronger than like?

R: I don't even think it's that I don't think they understand learning and attaining knowledge is not linear. You sit there absorbing is not the same thing as learning even critical thinking. I mean, if you hear the end of it, isn't it? It's acting right ? Ok, so, it's not passive to me.

P3: Yeah, I agree with you. (laughing)

R: Ok, moving on how can this experience lead to best practices in other subject areas for you? If it cannot please explain why, you feel it would not or cannot affect best learning practices.

P3: So, you are referring to the activities?

R: Yeah, either or both. So, basically can this experience lead to best learning practices in other areas for you? Could you use this to learn in other areas for yourself?

P3: Yeah, for sure 100% um so the school I'm going to like a lot of professors and guest lecturers (volunteers) have jobs in the business field. So, like they work in the city then come teach the students using real-life business examples. Like I'm very big on you can't learn business from a teacher alone. You have to learn business from a businessman or businesswoman. So, if you're going to ahead and think that you can learn business from a teacher or maybe you'll get it but you are not going to fully understand it, so there's a lot of businessmen and women who after work come and teach the students. Like they're not just lecturing but they're teaching actual business. They're doing analyzing real time examples and then showing how it applies but they are showing us like I just did this today and now tomorrow I have to do this. They are getting the kids involved in what they're working with during the day. I think that's really cool because again you're learning from someone who is actually doing it, not from someone who says I can teach you how to do.

R: That's two different types of experiences. You're correct, so in other words on top of the academic experience, you're getting a practical experience, which is technically now you're applying the information you just learned. It's active learning.

R: Ok. I would like to thank you so much for participating in the interviews. It has been good to see you. I will send the transcripts for you to member check within a week.

P3: You're welcome, Ms. Collier. Of course, if you need anything else for the interviews let me know. Take care

R: Take care and Thanks again!

Appendix F: Significant Statements: Horizons

Location of Significant Statement	Statement	Meaning Units
p. 3, Line No., 14-16	"So right I think the argumentation that we did was beneficial because I think that's the best way to learn to know if you have fully understood a topic." "But the next step of like really, truly understanding it is to uhm repeat it in your own words and really try to like work your way around the entire topic and figure out for yourselves like what's what"	• argumentation is beneficial • best way to learn • leads to ability to use your own words equals comprehension
	"I mean yeah, it was but you definitely capitalize on this method because you would say it in a way like as if, like you would question us like you would start interrogating us like, do you actually know what I'm talking about? Or are you just saying you know? You know like you would like deep down drill in the concept and be like don't give me no shenanigans! Do you understand it? We would answer correctly based on what we were doing, and you would say are you sure? Are you sure? we would answer confidently based on what we know but you would interrogate us at times (laughing). A lot I should say (laughing)."	• argumentation method implemented was intense • helped to understand • learn concepts • course load a lot
p. 3, Line No. 111-114 p. 3, line no. 114-116	"I think, uh, that you as the teacher was able to monitor the conversation and like steer us into the correct direction with case studies so if we are doing it by ourselves then students would get confused, it would be a little difficult to try to like work it out by ourselves." "But when you have someone who's knowledgeable like the teacher to like to navigate you around a certain topic. I think that works much better and then you get to really experience it, but also have the added benefit of having some guidance." " So, uh lecture you'd always diagrams out, so it would be important to see what you're talking about in lecture."	• argumentation is more effective in lecture • teacher is a knowledgeable source • teacher is required to facilitate active learning & argumentation to maintain focus on task • content is difficult without guidance of teacher • active learning (interactive diagrams) more effective to engage the learner to listen to lecture
p. 7, line No. 242-243 p. 5, line nos. 135-141 p. 5, line nos. 141-143	"I mean, I guess it depends on the person. For me, I don't think it would. I don't think it has ever negatively impacted me, but I guess somebody that learns better in different forms might not benefit from it. Actually, yeah, personally it was very beneficial to me." "Yeah, so for the most part it's definitely beneficial to like grasp concepts but I have to say (paused) like it's that everybody learns in a different way." "So, I mean every kid learns differently, like of course if you have like a 10 out of 10 student and you give him a case study. I'm sure he'll learn from it." "But the case studies are kinda like for the students to see like what they know. Also, what they're like engaging more into and like what to focus more on?"	• types of metacognitive teaching strategies • everyone learns differently • case studies for slow learners • progress checkpoints for slow learners • students need assessment based on learning style • might not work for every student

p. 11, line no. 328-331	"Limitations, hmm I mean, the only one I can really think of is that those rare students who they like the boring lectures and like they can just sit down like I guess it's taking away from them. But then again, those are like rare. I don't come across many of them but straight robots who can like sit down and listen to words."	
p. 3, line no. 121-122 p. 4-line no. 121-124 p.6-line no. 221-225 p. 6, line nos. 163-165 p. 7, line nos. 185-189 p. 11, line nos. 313-314 p. 11, line nos. 316-325	"So, one of the case studies that I remember most ok we did a kind of group argumentation on the spiked Tylenol capsules, and how it worked in the body." "I think the active debate was beneficial to the overall comprehension of the topics." " I really like how it was applicable to everyday life. So, with the case studies especially the Tylenol one where we had to learn what the symptoms meant and what went wrong. I thought that was very interesting and helped overall understanding of cellular respiration at the organelle level and what it does to the whole organism. Then definitely breaking up into groups and debating and having to defend my position was helpful in learning." Ok, there was a lab, but I only remember it so vividly because it smelled so bad. The lab with the fake vomit. We were trying to see what foods were digested. Oh, it smelled so bad and the color, Ms. Collier! "Oh, I remember a lab we did on a lab on what is in nail polish. We looked all the chemical structures for regular nail polish versus gel nail polish. I never knew like many differences are because of a small change in structure until we built the models. Oh, that was similar to the other lab where we built models for all the levels of a protein. So, it was helpful to see what you are talking about and like building it helped me to understand like you said hundred times structure and function." "I feel like it's a good checkpoint. You know you checkpoint for understanding and to know if everyone has got it then ok, let's move on." "So, like towards the end like nobody really understood chi square so you were like ok, I have to devote a one-day activity where we did a bunch of math activities but you made it fun. I like kind of understood because of previous math classes so like kind of like observed the class. And uh, it was one of the more complex topics in Biology, so people tend to be like not understand it as much as like other things. So, like people, I could see were like making tricks to learn it. Like, uh they were like ok what do I have to do like to understand this because I'm clearly not getting it and this confusing so like what tricks can I make to know this and remember this. So, like you know I saw that was a good checkpoint because people didn't understand it and I think after class people left with a better understanding even if some of them still had questions. But I think they had a good idea of like what to do on the test."	• case studies and argumentation helped to understand course content • real-life example increased understanding • using scientific evidence to solve the case.
p. 4-line No. 136-137 p. 3, line no. 100-101	"I think we definitely were able to learn in a better way than just being taught the lesson and just listening."	• teacher should not lecture the entire period • guidance • interacting with content through argumentation

p. 3, line no 111-112 p. 7, Line nos. 194-196 p. 6, line nos. 182-183 p. 7, line nos. 184-185	"It's one thing to listen to a teacher and to just absorb." "That you as the teacher was able to monitor the conversation and like steer us into the correct direction with the case studies so if we are doing it by ourselves then students would get confused, it would be little difficult to try to like to work it out by ourselves." It's a big difference. And for labs I feel like yeah, just hands-on experience that just gets the cognitive like the mindset like your just your brain is actively involved because like your hands were doing your eyes are observing like all your senses are involved in the assignment. So, like you're getting a good grasp for the concept. "Because if you're just looking at words and constant like talking, your kind of yeah, you're hearing but you're not listening. So, the diagrams make you listen, so you understand what is being taught." "And we would have to draw diagrams in our notes that kept us listening because we needed to know what was going in the diagrams and how it connected to the lesson."	• audio-visual presentations • case studies increased student engagement and learnings
p.	"You know like I know some people; they get it more when they're doing the lab because like they're engaged." "And the labs kind of feel the students out and see like what they know. Also, we engaged and focused more." "I mean, I guess you have to give homework like in every category but I know for me the labs were fun because I saw it as a fun learning activity." "You're wondering if that's like legit like this is actually what is supposed to be happening or like am I making this up so when you do a lab it's like not 50/50 anymore. It's like 100% that this is what it is about." " And if you learned it right and it's right in your head the first time then by all means great. But if you did have a slight misunderstanding of the topic or didn't get it, with the labs you can alter what you know was wrong and what's right now."	• active learning hands-on engages learner • more than argumentation • case studies are homework • extends understanding and comprehension
p. 4, line no. 147-150 p. 4, line no. 147-150	"I think how it's usually one person will take the initiative and take the leadership and then everybody else will kind of take their role like debating a certain topic." "Somebody who's knowledgeable in something and then another who's knowledgeable on something else. And it'll kind of form like a group with uh roles." "Right, so uhm, we had like an official lab group like, oh I don't remember who it was, but it was four and I remember like I don't wanna say any names but like one or two kids were like kind of not interested as me and the other kid, so it was taking away from the experience." "But, like, uh that was only on Friday, so like for the weekdays, we would have me, Daniel, Gilad, and Theo. We all understood each other and how we learned so we kind of understood how we should attack each other	• active learning and argumentation were beneficial in team-based activities • roles based on each person's ability (area of expertise/ learning style), • learning occurred in a better way, • excited to work out the problem • peer Perception • group roles align with task expertise and compatibility. • peer acceptance and support • peer perceptions and expectations in group work

	so I feel like obviously when you go to college like you're not going to know as many people but like at least for high school it's really those groups that you know is very important." " You have like an understanding or awareness of is this kid compatible with this kid like are they going to work together or is this one going to sit down and let the other one does all the work, you know? I think the group make up is very important like who your teammates actually are?"	
p. 7, line no. 231-235 p. 10, line nos. 288-291 p. 10, line nos. 303-311 p. 6, line 154-156	"Right, so yeah, I definitely think, uhm math. I'm a visual person. So, making diagrams of whatever we were learning helped especially you could see it written out but the in history it was used produce timelines for a series." "For example, it's global history, you differentiate like at the same time period what was happening in Europe and America." "But physics it's a little bit between bio and chem. Like there's a lot of concepts where if you don't see actual examples, your kind of just going to be like oh ok, I guess. But that's OK, I guess mentality, yeah? As physics gets more complicated and you truly don't understand it, you're really going to be shooting yourself in the foot. So, I think for physics it's a big deal, not so much for chem though." "I could think about that we had the same, uh, like structure of learning is engineering like, I really can't think of any other class because engineering it's very conceptual. What I mean there are different ways to understanding something in engineering so basically, we would learn to code then the teacher would say "oh, now with what I just taught you I want you to turn on the lightbulb. You have 10 minutes to turn on the lightbulb by plugging it into your computer and turning it on then make it flash two times." So, at the end like nobody had the identical code like that's near impossible. So, like we would have these like I could them lab. He would have these labs to like see what's working for you like it didn't matter what the next person was doing but it was like what is working for you in class." "Like when I was applying to college like I wanted to see like what colleges offer that hands-on experience and also like in the business field. One of the main schools that is notorious for doing that is Michigan Ross." "So, the school I'm going to like a lot of professors and guest lecturers (volunteers) have jobs in the business field. So, like they work in the city then come teach the students using real-life business examples. Like I'm very big on you can't learn business from a teacher alone. You have to learn business from a businessman or businesswoman. So, if you're going to ahead and think that you can learn business from a teacher or maybe you'll get it but you are not going to fully understand it, so there's a lot of businessmen and women who after work come and teach the students. Like they're not just lecturing but they're teaching actual business. They're doing analyzing real time examples and then showing how it applies but they are showing us like I just did this today and now tomorrow I have to do this. They are getting the kids involved in what they're working with during the day. I think that's really cool because again you're learning from someone who is	• active learning components (diagrams and charts) utilized in other subjects in school. • active learning at the post-secondary level

	actually doing it, not from someone who says I can teach you how to do."	
p. 4, line no. 159-163 Pgs. 9-10, line nos. 273-280	"I definitely think it had a positive impact. I think, uh, doing these case studies and arguing with other students is really helpful and just making sure I think it established this confidence because when you're arguing with somebody else, you have to really like, take a stand and so to get your message across clearly." "So that definitely helped with confidence in the topic in general cause you have better understanding of it overall." "Ok, so I'm going to speak on the labs because for the most part we did labs. Uh, it's definitely a confidence builder. Because when you are learning it, you have an idea, right? But the idea in your head you're not really sure about it. You're wondering if that's like legit what's actually supposed to be happening or like am I making this up. So, when you do a lab it's like not 50/50 anymore. It's like 100% that this is what it is about. And if you learned it right and it's right in your head the first time then by all means great. But if you did have a slight misunderstanding of the topic or didn't get it, with the labs you can alter what you know was wrong and what's right now."	• positive impact on learning • increased confidence

Appendix G: Significant Statements, Meaning Units, Theme Clusters, and Emergent Themes

Significant Statements	Meanings Units	Theme Clusters	Emergent Theme
• "So, right I think the argumentation that we did was beneficial because I think that's the best way to learn to know if you have fully understood a topic." (p.3 14-15) • "But the next step of like really, truly understanding it is to uhm repeat it in your own words and really try to like work your way around the entire topic and figure out for yourselves like what's what." (p.3 14-15)	Argumentation is beneficial, best way to learn, leads to fully understanding topic, ability to use your own words equals comprehension.	Argumentation and active learning Increased Comprehension	Awareness of active learning and argumentation increasing comprehension Educator Must Facilitate Strategies for student comprehension and engagement. (Subtheme)
• "I think, uh, that you as the teacher was able to monitor the conversation and like steer us into the correct direction with the case studies so if we are doing it by ourselves then students would get confused, it would be little difficult to try to like to work it out by ourselves." (p. 3 112-114) • "But when you have someone who's knowledgeable like the teacher to like to navigate you around us around a certain topic. I think that works much better and then you get to really experience it, but also have the added benefit of having some guidance." (p. 3 No. 114-116) • "So, uh lectures you'd always have diagrams out, so it would be important to see what you're talking." (p. 181- 184)	Argumentation is more effective in lecture, teacher is a knowledgeable source, teacher is required to facilitate active learning & argumentation to maintain focus on task, content is difficult without guidance of teacher. Diagrams included in lecture to engaged the student		
• "So, one of the case studies that I remember most ok we did a kind of group argumentation on the spiked Tylenol capsules, and it worked in the body." (p3. No. 121-122)	Case Studies and Argumentation helped to understand course content, real-life examples increased understanding of the topic by using scientific evidence to solve the case which tom understanding the topic.	Argumentation using Active Learning Increased Understanding, Comprehension	AL/ARG combined with real-life that connect to the content increases understanding and comprehension
• "I think we definitely were able to learn in a better way than just being taught the lesson and just listening." (p.4 No. 136-137) • "It's one thing to listen to a teacher speak and to just absorb." (p. 3 No. 100-101) • "Because if you're just looking at words and constant like talking like your kind of yeah, you're hearing but you're not listening. So, the diagrams make you listen, so you understand what is being taught." (p. 6 No. 182- 183)	Teacher did not lecture for the entire period, interacting with content through argumentation, audio-visual, & case studies increased comprehension.	Interactive Teaching vs Passive Teaching effects on learning and comprehension	Interactive teaching vs passive teaching affect how students engage and learn in sciences
• "I think how it's usually one person will take the initiative and take the leadership and then everybody else will kind of take their role as like debating a certain topic." (p. 4 No. 147-148) • "Or somebody who's knowledgeable in something and then another person who's knowledgeable on something else. And then it'll kind form like a group with uh like roles to solve the problem." (p. 4 No. 148-149) • "Right, so uhm, we had like an official lab group like, oh I don't remember who it was, but it was four and I remember like I don't wanna say any names but like one or two kids were like kind of not interested as me and the other kid, so it was taking away from the experience." (p.8 No. 240-242)	Active learning and argumentation were beneficial in team activities with roles based each person's ability (area of expertise), learning occurred in a better way, excited to work out the problem given in the case studies with team members. Group roles align with task expertise. Student is confident in the practical knowledge for the learning goal(s). Each member works towards solving problem in order to understand content topic.	Argumentation and Active Learning teamwork requires identifying of strengths and weaknesses to complete the learning goal. AL/ARG requires working with team members personalities and compatibilities	Peer perceptions, acceptance, and expectation in group work.

• "But, like, uh that was only on Friday, so like for the weekdays, we would have me, Daniel, Gilad, and Theo. We all understood each other and how we learned so we kind of understood how we should attack each other so I feel like obviously when you go to college like you're not going to know as many people but like at least for high school it's really those groups that you know is very important." (p. 8 No. 242-248) •			
• "I definitely think it had a positive impact. I think, uh, doing these case studies and arguing with other students is really helpful and just making sure I think it established this confidence because when you're arguing with somebody else, you have to really like, take a stand and so to get your message across clearly. So that definitely helped with confidence in the topic in general cause you have better understanding of it overall." (p. 4 No. 159-163)	Definitely positively impacted learning, increased confidence (self-efficacy) in science.	AL/ARG increased self-efficacy in AP	AL/ARG increased self-efficacy in AP Biology
• "Yeah, so for the most part it's definitely beneficial to like grasp concepts but I have to say (paused) like it's that everybody learns in a different way." • "So, I mean every kid learns differently, like of course if you have like a 10 out of 10 student and you give him a case study. I'm sure he'll learn from it." • "But the case studies are kinda like for the students to see like what they know. Also, what they're like engaging more into and like what to focus more on? I mean, I guess you have to give homework like in every category." • "I mean, I guess it depends on the person. For me, I don't think it would. I don't think it has ever negatively impacted me, but I guess somebody that learns better in different forms might not benefit from it. Actually, yeah, personally it was very beneficial to me."		Everyone learns differently, case studies were to see where the other type of learners were at with their comprehension, understood that all students need assessment based on learning style. Awareness of differentiated teaching for other learning types.	Differentiated Instruction can affect students differently based on learning style.