

INCORPORATING SCRIPTS WITH COOPERATIVE LEARNING TO PROMOTE  
CRITICAL THINKING SKILLS IN SECONDARY SCIENCE

by

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Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

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## ABSTRACT

A drastic growth of scientific and technological advancements in the 21st century have allowed for new jobs with innovative processes that require individuals who possess the ability to think deductively, reason through problems, and obtain information that can support the potential solutions to these problems. Many of the technological advancements have reduced the necessity to only memorize rote facts; rather, much of this information can be found through a quick internet search. What is needed, therefore, is education which requires students to think deeper than before – to examine new information through a more critical lens. The purpose of this research study is to investigate how the introduction of collaborative scripts into the cooperative learning of students in a secondary science classroom impacts critical thinking skills. A quasi-experimental non-equivalent control-group design was implemented. The sample was drawn from eight sections of ninth grade science at a secondary public school in a northeastern state. Students engaged in project-based learning with cooperation with peers on an inquiry-based science lesson with phenomena. The experimental group was presented with scripts to begin asking thoughtful questions of peers about the phenomena being studied. The control group was instructed to engage in peer discourse as they normally would. The CCT-X was administered to all participants as a pretest and posttest. The data was analyzed via ANCOVA testing. Although a greater improvement in scores can be seen in the group that was exposed to the cooperative scripts, the results were not statistically significant. Future recommendations were identified, such as recruiting a larger sample size, implementing a longer duration for the intervention of collaborative scripts, and considering a new instrument for measuring critical thinking skills.

*Keywords:* critical thinking, cooperative learning, collaborative scripts, peer discourse

## Dedication

I would like to dedicate this manuscript to my loving husband, Chris Wetherby, for the endless love and support he provided throughout this challenging and crucial stage of my life. Days that I spent delving into research, writing papers, and collecting data, he spent ensuring the house and errands were taken care of and that I stayed fed and undistracted. He always asked, "How can I help?" when I felt entirely too overwhelmed. Chris, I am blessed to call you my husband.

I would also like to dedicate this manuscript to my parents, Lee and Sharon DiSalvo, for always encouraging me to follow my dreams. They taught me from an early age that I could do and be anything if I only put the work and effort in. Mom and dad, I am blessed to call you my parents.

Finally, I would like to dedicate this manuscript to our Heavenly Father, whose guidance, love, and unwavering support has lifted me up time and again and instilled in me the perseverance to keep pressing on. "Have I not commanded you? Be strong and courageous. Do not be afraid; do not be discouraged, for the LORD your God will be with you wherever you go" (Joshua 1:9, NIV).

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### **List of Abbreviations**

Analysis of Covariance (ANCOVA)

Cornell Critical Thinking Test, Level X (CCT-X)

Institutional Review Board (IRB)

Statistical Package for the Social Sciences (SPSS)

Zone of Proximal Development (ZPD)

## **CHAPTER ONE: INTRODUCTION**

### **Overview**

Critical thinking skills are necessary to possess in the 21st century, as it is more crucial than ever that the information presented from a variety of sources be analyzed for authenticity (Colglazier, 2018). Additionally, innovations in the scientific and technological fields have resulted in an increase in jobs that require greater problem-solving capabilities (Abadzi, 2016). These skills can be taught in school (Colglazier, 2018; Toheri et al., 2020; Zapalska et al., 2018). This chapter discusses the historical background of educational pedagogy, beginning with educational reform during the Progressive Movement, and the development of learning theories that support the necessity of active engagement with one's peers during the learning and cultivation of new skills. In this chapter, the identified problem is presented, which supports the need for a research study in which instructional pedagogy and the development of critical thinking skills are investigated. The purpose and significance of the research study are articulated, and the research question which serves to guide the study is introduced, as well as the definitions for key terms.

### **Background**

In 1962, President John F. Kennedy delivered a commencement address at Yale University in which he stated: "Too often we hold fast to the cliché of our forebears. We subject all facts to a prefabricated set of interpretations. We enjoy the comfort of opinion without the discomfort of thought" (Jahanpour, 2015, p. 1). Nearly six decades later, one may find this statement to be just as thought-provoking as ever. With the current political climate and rich presence of unsubstantiated claims from a variety of sources, it is imperative for educators to equip students with the skills necessary to examine the claims presented, analyze all supporting

evidence, and, subsequently, formulate evidence-based arguments (Colglazier, 2018; Horn & Veermans, 2019). In addition, society of the 21st century has presented many innovative scientific and technological advancements, which will continue to shape civilization; today's students must be prepared with the skills necessary for jobs in these fields (Rampersad, 2020). Employers desire their candidates to possess skills such as the tolerance to work through uncertain challenges, ability to use clinical judgement (Penkauskienė et al., 2019), and creativity to apply effective solutions (Penkauskienė et al., 2019; Rampersad, 2020). Fundamentally, students must be provided with opportunities to cultivate the skills which are required to think critically in various aspects of life (Spector & Ma, 2019).

### **Educational Reform in the Progressive Era**

Discussions surrounding critical thinking in academia began approximately 2,500 years ago in ancient Greece. A philosopher named Socrates began questioning common beliefs. He emphasized clarity and logic as important concepts to one's thoughts (Paul et al., 1997). Socrates was followed by other philosophers: Plato and Aristotle, and, in the Middle Ages, Thomas Aquinas. These explorations continued throughout the renaissance period, as well as the 18th and 19th centuries (Paul et al., 1997). Critical thinking discussions were intensified toward the end of the 19th century; during World War I and the Progressive Movement, the Great Depression struck the country, and many adults became unemployed, while child labor became more prevalent (Guttek, 2011). Progressives began advocating for reform in education, claiming that a sound education for every child would result in leadership that would alter the bleak outlook for the country (Beatty, 2017). The desire was to remove children from laborious environments and place them in a position to potentially lead the United States to social, economic, and political reform (Guttek, 2011).

As a progressive thinker, John Dewey developed a theory regarding education through direct engagement, which differed greatly from the typical lecture-based methods of the time (Gutek, 2011). This theory expressed the need for students to investigate and discuss the content being learned. Such active engagement was called “learning by doing” (Dewey, 1897, p. 77). The argument extended from the belief that experiencing learning for oneself facilitates and unites physical and cognitive growth (Thorburn, 2020). These pragmatic views were contended by many, but they have provided a significant foundation for changes made regarding instructional pedagogy ever since (Holt, 2020).

### **Learning Theories**

Theories have since been developed which discuss learning as an active process, and it is evident that a social element is often promoted as well. Vygotsky’s (1978) sociocultural theory of cognitive development states children learn new concepts through the guidance of their peers – those who are superior in their knowledge. Through this theory, the concept of a child’s zone of proximal development (ZPD) is presented, which is the difference in the gap of knowledge a child can fulfill when guided by peers, in comparison to the learning that transpires without such guidance. Essentially, the theory claims that children are equipped with the physical and academic requirements to make connections from one topic to the next, but the intervention of scaffolded guidance is required to do so (Schunk, 2020). According to Gredler (2012), Vygotsky’s theory is often misunderstood as meaning the more knowledgeable peer must be actively involved in each stage of the learning process. Rather, the peer can be invisibly present, which is frequently observed in the educational setting as modeled problems to be solved, scaffolded activities to build upon one’s understanding, and peer discussions to facilitate one’s learning from one level of understanding to the next.

Bandura's (1977) theory of social learning claims children are observers of the environment and learn from the behaviors of others. As new behaviors are modeled by others, the observers constructively acquire information about those behaviors, but do not necessarily act upon them unless the motivation to do so is present. This theory was developed by research conducted by Bandura et al. (1961), in which it was found that children repeated behaviors they observed, unless a negative consequence was associated with those behaviors. In such instances, the children needed to be bribed in order to repeat the behaviors they saw. While new behaviors are learned through environmental observations, Bandura (1977) claims, one must also possess the motivation to repeat the behaviors. This theory of social learning has been extended to the educational setting, in which various motivational factors might be examined (Schunk, 2020).

Johnson and Johnson (2009) found that children in an educational setting are often motivated to engage in the learning process when cooperative learning methods are involved. During cooperative learning, students must work interdependently within small groups to achieve common goals. As students work together, each group member possesses a role that other group members do not. For this reason, each group member relies upon the others to contribute to and exert effort in the learning process; without such, the group cannot be successful in the attainment of its desired goals (Johnson & Johnson, 1999; 2009). The concept of cooperative work was first introduced by a psychologist named Morton Deutsch (Johnson & Johnson, 2018). Deutsch (1949) presented a theory which was originally intended for the industrial/organizational setting that pertained to motivation among teams of workers. Social interdependence was claimed to be the most beneficial work method because workers would feel a sense of obligation to their peers to contribute to the realization of goals (Deutsch, 1949). Johnson and Johnson (1999) found this theory to adapt well to classroom learning, as

interdependence among peers, and the accountability associated with such, motivated students to work alongside and learn from one another.

These theories have been valuable to the field of education, as they offer insight regarding the learning capacities of children – particularly in a social context (Schunk, 2020). Vygotsky's (1978) sociocultural theory of cognitive development provides a framework for connecting a student's knowledge from one concept to the next with the assistance of peers. Bandura's (1977) social learning theory conveys the importance of a student's social environment, as learning occurs through observing the modeled behaviors of peers. Deutsch's (1949) social interdependence theory offers a framework for motivating students to engage in and practice the skills being learned. The cooperative learning model, a framework for social interdependence, has become a widely used collaborative pedagogical structure, as it necessitates the effort and input of all group members to ensure the attainment of success towards identified goals (Johnson & Johnson, 2009).

### **Critical Thinking in the 21st Century**

The theoretical works of Vygotsky (1978), Bandura (1977), and Deutsch (1949) offer a foundation for arguing the importance of a peer-learning environment. The active and cooperative engagement and learning with one's peers may influence the development of greater cognitive skills, such as those associated with critical thinking (Loes & Pascarella, 2017). Unfortunately, a universal definition for critical thinking does not exist throughout the literature (Bailin et al., 1999; Sellars et al., 2018). When examining the various definitions utilized, however, common themes seem to emerge. Sellars et al. (2018) examined global contexts of critical thinking skills, along with varying social and cultural standards; the specific themes



which seem to recur throughout the research community are the ability to synthesize and analyze information, as well as formulate conclusions or devise solutions to problems.

While instructional pedagogies, such as peer collaboration, have been found to foster greater critical thinking skills (Abrami et al., 2008), a problem was identified in students' abilities to naturally engage in conversations that would make the learning more collaborative in nature (Johnson & Johnson, 1999). The implementation of collaborative scripts presents an instructional strategy to guide students through meaningful discourse (Olesova et al., 2016). Structuring peer discussions has been beneficial in directing students through the learning process in a scaffolded manner to increase learning outcomes (Vogel et al., 2017). It may be possible, therefore, that incorporating individual scripts, which guide students in synthesizing, analyzing, and problem-solving, may result in increased critical peer discourse. Introducing scripts to group members in a cooperative learning environment, as supported by Deutsch's (1949) theory of social interdependence, that are practiced by and modeled among peers, as supported by Bandura's (1977) social learning theory, may guide students in attaining new skills that allow greater critical thinking when sorting through new information, as supported by Vygotsky's (1978) sociocultural theory of cognitive development.

### **Problem Statement**

One of the most effective instructional methods to engage students in the practice and cultivation of critical thinking skills has involved peer collaboration (Fung & Liang, 2019). A wide array of research supports the implementation of peer discourse in the educational field as having a positive effect on students' development of critical thinking skills (Erdogan, 2019; Fung et al., 2016; Gillies, 2016a; 2016b; Lin et al., 2015; Loes & Pascarella, 2017; Singh & Kumar, 2015; Slavin, 1986). The problem with collaborative work, however, as described by Johnson

and Johnson (1999), is that not all groups of students work well collaboratively. Students possess varying levels of academic motivation (Chen et al., 2020; Kaiser et al., 2020; Karimi & Sotoodeh, 2020). Social interdependence in the form of cooperative learning was implemented in many instructional settings to account for differences in motivation; the accountability to one's group members ensured that each member of the group contributed to the peer discussions and learning (Cecchini et al., 2020; Forslund-Frykedal & Hammar-Chiriac, 2018; Guzmán & Payá, 2020; Johnson & Johnson, 2009; Kyndt et al., 2013; Slavin, 1983).

Even with such instruction, a problem still exists in students' ability to naturally engage in meaningful peer discourse (Gillies, 2016a; Le et al., 2018). Many research studies have been conducted to investigate how the use of collaborative scripts may enhance collaborative discussions by evoking purposeful and profound dialogue; collaborative scripts have been found to be beneficial for students in that regard (Lee, 2018; Lin, 2020; Ludvigsen et al., 2016; Näykki et al., 2017; Olesova et al., 2016; Tan, 2018; van der Meij & Leemkuil, 2019; Vogel et al., 2017). With such supporting research, it is necessary to investigate how the use of collaborative scripts in a cooperative learning environment may enhance students' critical thinking skills in the secondary science classroom. Research studies have been conducted to assess how collaborative scripts can be helpful at the university level (Harney et al., 2017; Hidayati, 2017; Saputra et al., 2019), but not at the secondary level in a cooperative learning science classroom – a subject in which much inquiry requiring critical thinking often transpires (Vieira & Tenreiro-Vieira, 2016; Whannell et al., 2018). The problem is that, while much research exists pertaining to cooperative discussions and the development of critical thinking skills, the literature is lacking on effective techniques for guiding meaningful discussions that will cultivate the critical thinking skills of students at the secondary science level.

### **Purpose Statement**

The purpose of this research study – with a quantitative, quasi-experimental, non-equivalent control-group design – is to investigate how the use of collaborative scripts can impact the development of secondary students’ critical thinking skills in science. To do so, eight classes of enrolled secondary science students at a school in a northeastern state were administered the Cornell Critical Thinking Test, Level X (CCT-X) as a pre-assessment and post-assessment surrounding the intervention of collaborative scripts (Ennis et al., 2005). The independent variable of this study is the type of instruction implemented. The experimental group utilized collaborative scripts, which can be defined as guided texts that foster productive talk about a topic among members of a group (Furberg, 2016; Ludvigsen et al., 2016; Tan, 2018; Vogel et al., 2017). The dependent variable measured in this research study is critical thinking skills, as measured by scores on the CCT-X (Demirci, 2017; Ennis et al., 2005; Erdogan, 2019; Yin & Fitzgerald, 2017). The covariate is pretest scores on critical thinking skills, as measured by the CCT-X. For this research study, critical thinking skills are defined as the ability to assess a problem or situation based on the evidence available and provide an argument with effective reasoning (Ennis & Millman, 1985). ANCOVA testing was employed to compare the critical thinking skills of both groups of students, while controlling for pretest scores (Warner, 2013).

### **Significance of the Study**

This study was conducted to test the use of collaborative scripts to gain insight regarding collaborative scripts as an instructional method in the acquisition of critical thinking skills among students in secondary science. The ability to engage in critical thinking in the 21st century is essential, as people must be able to analyze and question the information presented to them, organize solid arguments, and solve a variety of complex problems (Morris, 2017; Pilgrim

et al., 2019; Sellars et al., 2018). Many research studies have been conducted to examine how critical thinking skills can be cultivated in the classroom setting (Abrami et al., 2008; 2015; Alsaleh, 2020; Foo & Quek, 2019; Schindler & Burkholder, 2014). There are research studies that support the notion of incorporating collaboration into classroom instruction to increase the learning of critical thinking skills (Fung et al., 2016; Gillies, 2016a; 2016b; Lin et al., 2015; Singh & Kumar, 2015; Slavin, 1986). There are research studies which discuss the importance of cooperative peer discourse to ensure all group members are engaged in group discussions (Erdogan, 2019; Johnson & Johnson, 2009; Kyndt et al., 2013; Loes & Pascarella, 2017). There are also research studies that support the use of collaborative scripts in a groupwork environment to allow for peer discussions that are meaningful and successful throughout scaffolded instruction (Lee, 2018; Lin, 2020; Ludvigsen et al., 2016; Näykki et al., 2017; Olesova et al., 2016; Tan, 2018; van der Meij & Leemkuil, 2019; Vogel et al., 2017). No research, however, has discussed the use of collaborative scripts as a tool to guide meaningful and critical peer discourse to cultivate the learning of critical thinking skills in the secondary science classroom setting. This research study is significant because it investigated how the implementation of collaborative scripts in a secondary cooperative learning environment can foster the critical thinking skills of those students.

### **Research Question**

The research question is as follows:

**RQ1:** Is there a significant difference in critical thinking skills, as measured by the CCT-X, for secondary science students who engage in cooperative learning with scripts and those who engage in cooperative learning without scripts while controlling for pretest scores?

### Definitions

1. *Collaborative Scripts* – Guided texts that foster productive talk about a topic among members of a group (Ludvigsen et al., 2016; Tan, 2018; Vogel et al., 2017).
2. *Cooperative Learning* – Learning that occurs in small groups of students, in which members rely on one another to actively participate in order to achieve a shared goal (Johnson & Johnson, 1999).
3. *Critical Thinking* – The ability to assess a problem or situation based on the evidence available and provide an argument with effective reasoning (Ennis & Millman, 1985).
4. *Peer Discourse* – Productive discussions among peers meant to reason through the information being examined (Khong et al., 2019).
5. *Social Interdependence* – The dependence upon – and between – peers within a group to achieve a shared goal (Johnson & Johnson, 1999).
6. *Zone of Proximal Development* – The gap in knowledge a child may fill when offered guidance from a more educated peer in comparison to the learning that may ensue without the presence of such guidance (Vygotsky, 1978).

## **CHAPTER TWO: LITERATURE REVIEW**

### **Overview**

To address how the implementation of collaborative scripts with cooperative learning impacts the development of students' critical thinking skills in the classroom, a review of the existing literature pertaining to instructional pedagogy and critical thinking skills was conducted. The theoretical framework is discussed; Vygotsky's (1978) sociocultural theory of cognitive development, Bandura's (1977) social learning theory, and Deutsch's (1949) social interdependence theory each provide foundational support for the topic of study. Recent literature, including research studies, literature reviews, and meta-analyses, are presented to address the definition and necessity of critical thinking skills, peer discourse and cooperation, and the implementation of scripts to guide meaningful discussions. The theoretical framework and current literature are discussed in terms of how the research topic pertaining to cooperative scripts and critical thinking skills is informed. The chapter concludes with a brief synthesis of the information presented, as well as the identification of a gap that exists among the literature which supports the necessity of this study.

### **Theoretical Framework**

The use of collaborative scripts to engage in peer discourse is the focus of this research study. The social aspect of one's environment is quite influential in the learning that transpires regarding new concepts (Bandura, 1977; Deutsch, 1949; Vygotsky, 1978). When children learn through the scaffolded guidance of peers, they are more capable of making connections between concepts (Vygotsky, 1978). They learn how to engage in new behaviors (such as different learning or thinking processes) when they observe these behaviors being modeled by others in their social environments, but only engage in the new behaviors if they are sufficiently motivated

to do so (Bandura, 1977). In the classroom setting, motivation can be instilled through cooperative work (Johnson & Johnson, 2009). As each group member relies on the efforts of the others, a sense of accountability is presented that inspires all members to make progress towards shared goals (Deutsch, 1949). Learning theories that support the importance of one's social environment in the learning process provide a valuable framework for research in which peer discourse fosters the development of critical thinking skills in the classroom.

### **Sociocultural Theory of Cognitive Development**

Vygotsky's (1978) sociocultural theory of cognitive development states children learn from peers within their cultures who possess greater knowledge, as well as the ability to guide others through the process of gaining new knowledge. It is communicated that children possess the physical components to learn new information, but, mentally, they require the guidance and scaffolding of their expert peers to effectively make the cognitive connections between one topic and the next. According to Hardcastle (2009), Vygotsky's theory was mostly influenced by the ideas of enlightenment thinkers, Wilhelm von Humboldt and Karl Marx. Communication – particularly language – was believed by von Humboldt (1836) to be the most important aspect concerning the learning of new information (Hardcastle, 2009). He stated that the development of language requires a procedural, or structured, analysis, rather than a simple objective to be learned, and also communicated that the relationships between the different constructs which make up a language are categorized by an individual through a variety of schema, allowing one's understanding of language to be expanded upon (von Humboldt, 1836). Just as von Humboldt conveys the development of language is made possible via a schematic cultivation of the various language constructs, Vygotsky claims one's knowledgeable peers – similar to language schema – are able to provide scaffolded support for the learning of new material (Hardcastle, 2009).

Karl Marx was considered to be an intellectual theorist of the 19th century who despised capitalist German society (Ahmad, 2015). Marx (1867) vehemently encouraged the oppressed working class to rebel against the exploitation of skilled labor by higher societal classes. Much of Karl Marx's works went unpublished during his lifetime, but two of his writings: *Manifesto of the Communist Party* (1848), which was co-written with German philosopher Friedrich Engels, and *Capital: A Critique of Political Economy* (1867), are among his most well-read works (Ahmad, 2015). Marx was a strong believer that the conscious thoughts and behaviors of humans are directly molded by the conditions of their social classes from a young age (1867). Hardcastle (2009) interprets this to mean that children's social environments are what foster cognitive growth, and, consequently, education is dependent upon the environments in which the children evolve.

Roth and Lee (2007) expand upon this view by drawing attention to Marx's observations of diverse social classes. It was noticed that labor was divided among society, as jobs seemed to be dependent upon one's social class; people of varying social classes contained different sets of skills to contribute to society, as well as different ways of viewing social norms (Marx & Engels, 1848). This was attributed to the learning that occurred within each of the social classes, which according to Marx and Engels (1848), hindered the potential of many. Marx (1885) claims that one's knowledge stems from "the material world reflected by the human mind and translated into forms of thought." This seems to imply that the ways in which humans develop cognitively, as well as what concepts are learned are limited by the conditions with which they are presented within their own environments, as Hardcastle (2009) suggests. The importance of one's culture in Vygotsky's (1978) theory seems to exemplify such a notion. In fact, Jornet (2018) refers to Vygotsky's theory as Marx's finished theory.



Though Vygotsky may have been influenced by the ideas of von Humboldt and Marx, his theory emphasized the importance of one's peers in the learning process. He alluded to a concept in which children build upon their knowledge through scaffolded guidance. The concept of one's zone of proximal development (ZPD) was presented as the gap in knowledge a child may fill when offered guidance from a more educated peer in comparison to the learning that may ensue without the presence of such guidance (Vygotsky, 1978). A child's ZPD is entirely dependent upon the instruction provided; the placement of strategic scaffolds can allow children to make the necessary connections between their current knowledge and the next set of concepts to be learned (Gredler, 2012). The interactions which must transpire during this process, according to Hardcastle (2007), relate back to the importance of communication as described by von Humboldt in the enlightenment era.

### **Social Learning Theory**

Bandura's (1977) social learning theory indicates the importance of one's social environment in the learning process as well. The theory states that children learn new behaviors through the observations of others, called models, and that, while a behavior is learned, it is not necessarily repeated unless the motivation to do so is present (Bandura, 1977). The famous Bobo doll experiment conducted by Bandura et al. (1961) was very influential in the development of social learning theory. In this experiment, a group of children watched an adult enter a room and begin acting aggressively towards a large doll. Once the adult left the room and the children were permitted to enter, the children repeated the actions towards the doll that they had first observed being acted out by the adult. A second group of children watched the same scenario, except they observed the adult subsequently be punished for his actions. When the second group of children entered the room, they did not repeat the actions they had just observed until they were

eventually bribed to do so by the researchers. The actions from the two groups of children led researchers to believe that the observed behaviors were learned, but not necessarily acted upon. It was concluded that behaviors learned through observations are only performed if the observer is motivated to do so (Bandura et al., 1961). The results of this research were vastly cited in arguments pertaining to violence in video games; as the theory continued to gain popularity, implications were made to the educational setting in relation to working with peers in the learning process (Schunk, 2020).

### **Social Interdependence Theory**

Deutsch's (1949) social interdependence theory also places emphasis on one's social environment. The theory claims that work done with peers, in which the cooperation of all group members is required, increases the chance of reaching success. This theory has been widely adhered to in educational settings – particularly concerning group work and learning outcomes (Johnson & Johnson, 2009). According to Johnson and Johnson (2018), Deutsch constructed this theory from the ideas of several preceding him. Kurt Koffka (1935), who was a psychologist in the early 20th century (Johnson & Johnson, 2018), claimed that a group of people form a dynamic whole, and that the dynamic whole is most successful at meeting desired objectives when reliance upon one another is present. Kurt Lewin, an organizational psychologist, extended this claim and formulated a theory that interdependence upon group members allows each member to reach individual goals; essentially, an exchange of support promotes the interests of each person involved (Johnson & Johnson, 2018). Lewin (1935) refers to interdependence within teams as a group of forces which forms a dynamic whole. Essentially, each member acts upon the other, and a change in the actions of one member impacts the functioning of the rest of the group (Lewin, 1935). According to Johnson and Johnson (2018), Deutsch altered this theory to

pertain to interdependence among group members to work towards shared goals. Each group member in this scenario is accountable to ensure mutual goals are met at the benefit of all parties involved (Johnson & Johnson, 2009; 2018).

The purpose of interdependence is to compel motivation through shared obligation (Deutsch, 1949). Though the theory was first intended for use in the industrial and organizational fields, it has been tailored to the educational setting, in the form of cooperative learning, to increase the learning outcomes of students (Johnson & Johnson, 2018). Learning in a group social setting – particularly one in which cooperation is present – has been found to be quite successful; Johnson and Johnson (2009) discuss the wide array of research that has been conducted on social interdependence over the past 110 years, explaining that strong external validity exists, as the findings of many studies consistently yield the same results – even among varying cultures and within diverse areas of the world. It is communicated that by reviewing such literature, cooperative learning, which focuses on social interdependence, has consistently been shown throughout research studies to be one of the most effective instructional methods in classrooms, with an effect size of .64 in academic achievement, .70 in social support, .44 in positive self-esteem, .97 in reasoning abilities, and .42 in optimistic attitude towards learning when compared to individualized learning (Johnson & Johnson, 2009). The benefits of social learning in this aspect are clearly communicated, and the theory of social interdependence is supported as an educational framework.

### **Peer Guidance, Modeling, and Interdependence**

Vygotsky's (1978) sociocultural theory of cognitive development, Bandura's (1977) social learning theory, and Deutsch's (1949) social interdependence theory each offer substantial support to the topic of implementing collaborative scripts in a cooperative learning environment

to cultivate critical thinking skills among students. Structured peer discourse serves as a guiding scaffold, as supported by Vygotsky's theory (Gredler, 2012). The proposal is that students will reach the next stage in educational development – the ability to think critically – as they are guided in a peer setting through new thinking processes. Their ZPDs in this sense, therefore, may be realized more successfully (Vygotsky, 1978). As students work through these new thinking processes with the content being discussed, the opportunity for academically stronger peers to model effective use of the scripts is presented, thus allowing the student group setting to be one in which new behaviors may be learned, as supported by Bandura's (1977) theory. As students work cooperatively, they become dependent upon one another to work through different aspects of the content as they work through their scripts to pose new ideas and questions to be explored, as supported by Deutsch's (1949) theory. The theoretical frameworks being adhered to throughout this topic provide a strong foundation for gaining new insight into how students may be supported in the classroom to develop the skills necessary to think more critically about the content being learned.

### **Theoretical Frameworks to Inform Research**

The theories of Vygotsky (1978), Bandura (1977), and Deutsch (1949) have served as a foundation for much of the literature surrounding the topics of cooperative learning, collaborative scripts, and critical thinking skills. Deutsch's (1949) theory of social interdependence has informed decades of research for Johnson and Johnson (2018) in examining how cooperative learning in the classroom setting can lead to increased peer discourse and accountability among students. Many researchers have utilized this theoretical framework in conjunction with Vygotsky's (1978) sociocultural theory of cognitive development to determine how such a peer dynamic can build upon the development of critical thinking skills (Fung et al.,

2016; Harahap & Surya, 2017; Lin et al., 2015; Loes & Pascarella, 2017; Wyman & Watson, 2020). Bandura's (1977) social learning theory has been exhibited through the use of collaborative scripts, allowing students to engage in more meaningful interactions with their peers, as they observe and learn from the discourse of others (Lee, 2018; Lin, 2020; Ludvigsen et al., 2016; Näykki et al., 2017; Olesova et al., 2016; Tan, 2018; van der Meij & Leemkuil, 2019; Vogel et al., 2017). Research in which collaborative scripts are implemented and critical thinking skills are measured among a secondary science population may advance the three theories by strengthening their relevance to learning, demonstrating how all theories contribute to one scenario – possibly alluding to common themes which link the diverse set of frameworks, and offering a new perspective regarding how the frameworks may be applied successfully in an academic setting.

### **Related Literature**

It is necessary for students to learn and understand the content for a variety of subjects within their classrooms, but the critical thinking skills that would be required to synthesize, analyze, make arguments about, and solve problems regarding the content can and should be taught as well (Ennis, 2018). Holmes et al. (2015) claim that many students are not being provided the opportunities to practice these types of skills and are, therefore, less exposed to and less equipped with the thinking processes that critical assessment entails. With the recognition of social learning benefits through theory (Bandura, 1977; Deutsch, 1949; Vygotsky, 1978) and many research studies (Johnson & Johnson, 2009), it can be stated that implementing structured peer discourse, in which students are prompted to discuss the content through more profound approaches, may allow students to develop improved critical thinking skills.

## **Critical Thinking in the 21st Century**

The complexity of which students think about the information they learn has been organized into a taxonomical structure, with memorization and comprehension requiring less profound thinking, and actions, such as creating a product or idea and evaluating the worth of current products or ideas, requiring the most profound thinking (Bloom, 1956). The efforts which have driven advancements in science, technology, medicine, etc. throughout the 21st century involve complex thinking processes such as evaluation and creation; this type of thinking can be facilitated among children in the educational setting (Colglazier, 2018; Toheri et al., 2020; Zapalska et al., 2018). When students are thinking critically about the content, they are engaging with and making sense of various phenomena of the surrounding world (Sieroka et al., 2018). Such engagement requires active learning, which involves questioning and investigating, as opposed to lecture and note-taking (Kusumoto, 2018). Structuring pedagogy to ensure students are actively engaging in their learning can provide children with a chance to develop the critical thinking skills that will be needed for further advancements throughout society in the 21st century (Zapalska et al., 2018; ŽivkoviE, 2016).

### ***A Need for Critical Thinking***

The necessity of critical thinking skills is not a new concept. Williams (2016), for example, explains how deeper analysis of societal problems has been essential throughout the last four centuries to examine emerging issues such as racism, human rights, poverty, and political policies, as well as alliances and strategies in warfare. The 21st century, however, presents an additional set of concerns which humanity must be prepared to confront. Horn and Veermans (2019) discuss an increasing concern regarding media literacy, in which many people are willing to accept unsubstantiated claims made through social media outlets, without

questioning or verifying the validity of such. Pilgrim et al. (2019) expand upon this by suggesting as more critical thinking skills are taught and applied, the literacy of citizens can improve. In an era of such robust availability in technology, the need to implement profound thinking methods is more necessitous than ever (Sousa & Wilks, 2018). An increase in critical thinking skills can lead to more rational dialogue that may assess claims, ideas, policies, and products through the questioning and application of available evidence to address areas which can be improved upon throughout current and future civilizations (Morris, 2017; Sellars et al., 2018).

With technological and scientific advancements being made to better the lives of all people, employers are expecting and seeking candidates who possess the thinking skills necessary to continue to make improvements (Baird & Parayitam, 2019; Campbell & Kresyman, 2015; Cruz et al., 2020; Desai et al., 2016; Pearl et al., 2019; Penkauskienė et al., 2019). The ability to problem-solve effectively is one of the most important skills many employers allude to (Pearl et al., 2019; Penkauskienė et al., 2019). To problem-solve, one must be able to evaluate, analyze, and reason through the information provided; these are all skills pertaining to critical thinking (Ennis, 2018). According to Baird and Parayitam (2019), critical thinking skills are indispensable to the workforce, and educators possess an ethical and social responsibility to expose their students to opportunities to acquire such skills.

The focus on content throughout much of education has neglected opportunities for insightful thinking (Co, 2019). With such a wide availability of almost any desired information through internet search engines, less of an emphasis must be placed on memorization; more instruction must involve engagement through investigation (Garrison, 2016; Kusumoto, 2018; Wang & Mu, 2017; Zapalska et al., 2018). Such instructional processes force narrow thinking to

encompass more analytical and productive components through practice involving real-world applications (Paul, 2018). As Rönnlund et al. (2019) rationalize, such skills are essentially life skills, as they are applied to everyday occurrences. For instance, one must evaluate several options before making major financial decisions, offer evidence when defending an argument, and question claims before accepting them as truth. Critical thinking is a life skill. Equipping humanity with these skills through education is paramount to the continued enhancement of society (Cruz et al., 2020; Desai et al., 2016; Kusumoto, 2018; Sellars et al., 2018).

### ***Critical Thinking Defined***

Although there is no shortage of literature pertaining to the concept of critical thinking skills, a unanimous definition of the concept does not exist. Ennis (2018) defines critical thinking as “reasonable reflective thinking focused on deciding what to believe or do” (p. 166). Hansson (2019) refers to critical thinking as “well-founded reasoning” (p. 5). Tan (2017a) simplifies critical thinking as regarding the use of one’s judgement. Larsson (2017) considers all definitions of critical thinking to be too generic, as they cannot possibly capture the complexity of what critical thinking truly entails. Johnson and Hamby (2015) refuse to define critical thinking, explaining that the diverse and intricate aspects of the concept extend far beyond a simple definition and that those who have created definitions are not thinking critically about what critical thinking means.

Through all the contributions to the current body of literature, however, common themes can be devised. Action verbs such as analyze, evaluate, reason, and problem-solve are found repeatedly throughout the literature that discusses critical thinking (Abrami et al., 2008; Ennis, 2018; Erdogan, 2019; Fung et al., 2016; Garrison, 2016; Zapalska et al., 2018). To clarify further reference to critical thinking skills in this paper, the following definition will be adhered to: The



skills which allow a person to analyze the information available about a given topic to evaluate and solve a problem, create a new product or idea, or reach a conclusion that can be supported with evidence. This definition, as conceived from the common themes among relevant literature supports subsequent discussions regarding critical thinking.

### **Peer Engagement and Learning Theories**

A meta-analysis conducted by Abrami et al. (2008) evaluated various instructional methods in education as they relate to the development of critical thinking skills. Though not all results were clear, what was ultimately learned is that “pedagogy matters” (p. 1121); the cultivation of critical thinking skills is dependent upon the instructional pedagogy of the classroom. Engagement with the content being learned, in any fashion, was more productive in the development of critical thinking skills than traditional, lecture-based formats. Theories from Vygotsky (1978) and Bandura (1977) each support the notion that learning best occurs through engagement with one’s social environment. For this reason, it is proposed that instructional pedagogy which emphasizes peer learning is beneficial in the development and application of critical thinking proficiencies.

### ***Cognitive Development Through Peer Engagement***

Murphy et al. (2018) found that engagement – particularly through analytical peer discussions – was positively impactful on learning outcomes. Gratton (2019) reports on a research study in which the results support the peer learning process in the cultivation of many new abilities, including autonomous learning and enhanced social and communication skills. Loes et al. (2018) found an increase in interactions among a diverse population of students, which allowed for new perspectives to have shaped their investigations and learning experiences. These results are consistent with Vygotsky’s (1978) sociocultural theory of cognitive

development; students learn new information through guided and scaffolded work with their peers. As students work together, through collaborative discussions, they connect newly learned concepts with those which they already possessed. Gredler (2012) explains that Vygotsky's theory has been misunderstood by many throughout the educational field, as the knowledgeable individual in the scenario is not required to be actively involved in the learning investigations that transpire.

Vygotsky also identified situations in which the child can function in his or her ZPD without overt assistance. The school child who solves problems on the basis of a model he [or she] has been shown in class is an example. The help from the teacher is invisibly present. (Gredler, 2012, p. 119)

In this way, the instructor facilitates the learning process, through which students may realize their ZPDs, without a need for continuous intervention. Rather, the peer discussions which transpire are carefully structured by the instructor in advance to serve as the scaffolded guidance throughout the learning process. Such practice supports the claim that instruction does not require the incorporation of complex and abstract concepts which are directly taught by one's peers, as is a common and early misconception of Vygotsky's theory; rather, strategically placed instructional scaffolds can serve as the guidance from a more knowledgeable other in the learning scenario (Gredler, 2012).

### ***Peer Discourse and Critical Thinking***

As students work together to discuss the content being learned, they fundamentally serve as models for one another. Peer discourse allows for thinking concepts and strategies to change and transfer from one student to the next (Lin et al., 2015). As Bandura's (1977) theory states, children learn new behaviors through the observation of models. Such transfer of skills, as they

are practiced in the classroom setting, support that theory. Many recent research studies indicate that peer discourse in the learning environment results in gains in critical thinking skills (Kuhn, 2018; 2019; Loes & Pascarella, 2017; Singh & Kumar, 2015). These skills, as they are observed by each student, are developed further. For example, research by Effendi-Hsb et al. (2019) suggests students' argumentation skills are strengthened as they practice and observe one another through classroom debates. Fung et al. (2016) found only minimal teacher intervention to be necessary in classroom debates, as students learned from each other's argumentation skills, as supported by Bandura's (1977) social learning theory, allowing students to reach greater skills in argumentation, themselves, as supported by Vygotsky's (1978) sociocultural theory of cognitive development.

**Purposeful Discussions and Processing.** Peer discourse is beneficial in the development of critical thinking skills among school-aged children because it compels students to think more profoundly about the information they are learning (Kuhn, 2018; 2019; Murphy et al., 2018; O'Halloran, 2017). According to Erickson (2019), instructional pedagogy in schools is often centered around finding the "right answer" (p. 211), rather than the thinking processes involved in doing so. Intellectual conversations within the classroom environment allow students to process their thoughts about the content, rather than memorize and recite the correct answer (Erickson, 2019; Repice et al., 2016). Backer (2017) advocates for the incorporation of classroom dialogue and implores others to examine such discourse from a psychological lens to better understand why it leads to more critical thought. As introduced in Aristotle's theory of Democracy, Backer (2017) explains that authority, or rule, is taken in turns to prevent any one person from possessing an authoritative status for too long. When a person takes on a role of authority, they are no longer themselves – rather, they have become an entity that serves the

needs of others. When students become facilitators of discourse, they are no longer just participants in the discussion; they have taken ownership of the collaborative environment. They have begun to facilitate the conversation in turns, rather than participate in turns. Assuming a role which takes ownership of the process allows for more active engagement to transpire (Backer, 2017). Classrooms often take the form of a monarchy, rather than a democracy, as the teacher facilitates, or presides over, classroom discussions and the students become mere participants; alternatively, more purposeful dialogue is enabled when students are presented the opportunity to adopt the persona of the facilitator, rather than that of the participant – to lead meaningful discussions among their peers regarding the content being learned (Backer, 2017).

Ingram and Elliott (2020) explain that academic topics are often covered in a superficial manner, rather than comprehensively, which presents less of an opportunity for the newly-learned content to become attached to a meaningful schema – and the development or understanding of such schema is an essential component of learning, according to Vygotsky's (1978) sociocultural theory of cognitive development. Even if students do connect the new information to an existing schema, Wilberding (2019) explains that the processes implicated in the learning of simple facts often lack the components of critical analysis. For example, it is simple to deduce that a cube cannot fit into a circular shaped hole, but critical thought is necessary to understand why it does not fit or for creating a plan to try to make it fit. Such thoughts can lead to problem-solving endeavors or deeper philosophical questions which may drive further quests for knowledge. Attaching one's learning of the cube and circular hole to multiple schemes would be, according to Wilberding's (2019) articulation, critical thinking.

Peer discourse in the academic setting allows for such thinking to occur on a “social plane” (p. 550), as processing can transpire to assist one in creating meaning from the content

(Tang, 2017). The teacher, as the more knowledgeable other, incorporates peer discussions as scaffolds to allow students the opportunity to fill gaps in their learning and, ultimately, realize their ZPDs (Gredler, 2012), as first introduced by Vygotsky (1978). The differing perspectives and levels of understanding from a diverse set of peers can provide new insight that either fills gaps in one's comprehension or creates new gaps to be filled through further discourse (Heller, 2017; Markee, 2015). For example, Spierenburg et al. (2017) presents a science lesson with phenomena in which students' misconceptions regarding an exploding flask in a chemistry classroom can be resolved through group discourse, as students learn more about chemical reactions. Students can ask questions of one another regarding their thoughts of the gaseous mixture in the flask, and compare it to their learning, to ultimately determine the true chemical processes involved in the explosion. The various ideas and questions presented by different members of the group would allow for analytical discourse to transpire (Spierenburg et al., 2017).

Access to such differing perspectives, which instigate new ways of thinking about various topics, is why peer discourse is instrumental in the development of critical thinking skills (Heller, 2017). Rapanta and Christodoulou (2019) found that the process of constructing and delivering arguments in an academic setting can influence students to think more analytically, as new perspectives are examined and considered. Similarly, it has been found that students tend to think more critically about mathematics concepts when peers explain their thoughts because students are provided the opportunity to examine the significance and varying processes pertaining to their work (Calkins et al., 2020). Through conversations such as these, students have been successful in assessing the reliability of various sets of information (Pérez et al., 2018), and differentiating science from pseudoscience (Quinn, 2015). According to Rumenapp

(2016), teachers' perspectives of their students' identities shifted as students engaged in discourse that demonstrated different thinking perspectives. This supports the notion that the different perspectives of students become evident when students engage in critical conversations with their peers.

**Social Learning.** Ahn et al. (2020) claim that when people are asked to articulate their most significant influences in life, they often name specific individuals who they believe to have been instrumental in shaping their psychological growth, behaviors, and beliefs. Role modeling, involving observational learning, is a widely recognized learning approach, though the cognitive processes which are entailed remain poorly understood (Horsburgh & Ippolito, 2018). Bandura's (1977) social learning theory is cited abundantly throughout the literature, and its implications in the educational field are substantial (Marić et al., 2017). Ahn et al. (2020) explain that as students observe the behaviors of their peers in the school environment, they note the positive and negative consequences associated with those behaviors and, consequently, learn to imitate or refrain from replicating such actions. This results in the learning of new and accepted norms among adolescents, such as smoking nicotine (Scalici & Schulz, 2017), drinking alcohol (Boyle et al., 2016), contemplating or acting upon suicidal ideations (Petrova et al., 2015), and engaging in delinquent behaviors (Kim & Fletcher, 2018). If an observer considers the outcomes of a peer's modeled actions to be desirable in some manner, the behavior is learned as one that should be repeated by the observer (Marić et al., 2017). Likewise, the learning and acceptance of new behaviors can occur in terms of acquired academic skills in the classroom setting (Ahn et al., 2016; Raedts et al., 2017).

Wang and Gu (2019) researched the role of peer influence on one's academic identity, explaining academic identity to be a person's behaviors, competencies, feelings of self-efficacy,

and disposition towards learning in an educational context. It was found that engagement with one's peers through social platforms was influential in determining one's academic identity. Research by Urlacher et al. (2016) offers direct support for such findings; it was found that students with learning disabilities in an inclusive academic setting seemed to assimilate the academic behaviors exhibited by their typically-developing peers – particularly regarding commenting during instances of academic peer discourse. This was attributed to observational learning among peers, as indicated by Bandura's (1977) social learning theory. Spriggs et al. (2016) offered similar research findings pertaining to observational learning. In this study, children with autism learned to engage in age-appropriate play and gained new skills regarding such actions through observational processes.

Students' beliefs in their own abilities to achieve success on various academic tasks are impacted by observing modeled examples from others (Ahn et al., 2016; Hidayat & Ramli, 2019; Hoogerheide et al., 2016; van der Loot et al., 2019). With such implications of social learning in the educational setting, it is practical to apply social learning opportunities to develop students' thinking about the content being learned in the academic environment. Harris et al. (2017) found that discourse in the secondary science classroom was beneficial to students' thinking processes regarding the science concepts, as the teacher modeled questioning and deeper engagement with the content. This notion is supported by research conducted by Khong et al. (2019); it was found that productive talk in the classroom, in which the teacher promotes relevant discourse among the students while prompting deeper and more meaningful inquiries about the topic, allowed students to begin asking the same types of critical questions in subsequent peer discussions – without the condition of prerequisite prompting. Zubiri-Esnaola et al. (2020) conducted research in which interactive groups of students were structured within the classroom to allow for greater

participation and collaboration in learning English as a second language. It was found that as students worked together to engage in learning the language, the academically stronger students were able to serve as models for their peers, and the students who had not previously exhibited significant gains in their learning of the language demonstrated greater academic growth in this regard. Research studies such as these provide valuable insight regarding collaboration and cooperation among peers within a learning community in terms of Bandura's (1977) social learning theory.

### ***Benefits of Cooperation***

Although it has been reported that collaborative efforts are significantly beneficial to the learning process (Corcelles & Castelló, 2015; Gillies, 2016b; Kuhn, 2018; 2019; Murphy et al., 2018; O'Halloran, 2017), and even in regard to the development of critical thinking skills (Amrullah & Suwarjo, 2018; Erdogan, 2019; Isjoni, 2017), they can be detrimental when not structured strategically (Gillies, 2016a). As Johnson and Johnson (1999) explain, much of group work involves hard-working members who ultimately are left feeling "exploited" by the less engaged members who benefit from a "free ride" (p. 68). Deutsch's (1949) social interdependence theory explains goals can best be achieved when all members of the group are reliant upon the efforts and contributions of the others; this must be structured so the group cannot be successful without those conditions being met. This theory has been adapted to the classroom environment, being referred to as cooperative learning, to ensure all students in a groupwork setting are fully engaged, as they are motivated by a sense of accountability to their peers (Johnson & Johnson, 2018). Ensuring each student has an active and valuable role in the learning process allows for the opportunity of collaborative learning goals to be met by all (Johnson & Johnson, 1999). This works well when it can be ensured that meaningful interactions



take place among members of the group; a problem exists, however, when the instructor does not implement or know how to incorporate structured peer discourse among students (Gillies, 2016a; van der Meij & Leemkuil, 2019).

**What it Means to Work Cooperatively.** Research conducted by van Bunderen et al. (2018) delivered interesting results concerning functional and dysfunctional team conflict. Groups of people working in competition against one another were less likely to fully engage in work tasks and be successful at reaching their goals than the groups of people who worked together. It was observed that there were less “power struggles” and more sharing and pooling of essential resources in cooperative teams (van Bunderen et al., 2018, p. 1111). For example, sports teams, as referenced by van Bunderen et al. (2018), tend to work interdependently in a cooperative fashion; the success of the entire team is ultimately dependent upon each of its members – instilling a sense that success can be achieved through teamwork. One may apply this concept to working teams in any other setting (van Bunderen et al., 2018). High performing teams – when working cooperatively – do experience team conflict, but it is functional conflict which drives the ideas and performance of the overall team in a positive direction (Wheelan, 2016). When open communication is fostered among members of a team, members may find conversations to be uncomfortable at first, but these open discussions allow for learning to transpire from the diverse perspectives of others (O'Neill & McLarnon, 2018), which can foster the necessary creativity, innovation, and critical thinking processes that guide the team’s endeavors (Wang et al., 2020).

During cooperative work in the academic setting, the focus shifts from the teacher to the students; the students take ownership of their learning and become the “protagonists” (Duran et al., 2019, p. 25). For cooperative learning to be effective, several components must be evident.

Positive interdependence must be present; students must believe that the success of the group is dependent upon the work and efforts of all members. Individual students must be held accountable for leading the group towards success. A sense of equality is emphasized; no group members are to be excluded and no group members are to dominate. Additionally, the group must experience a sense of autonomy; members must rely on one another, rather than the classroom instructor, for success (Gillies, 2016a; Goodyear, 2017; Jacobs & Renandya, 2019; Johnson & Johnson, 1999). Such a structure fosters communities of learning among students within which social learning processes may transpire (Farnsworth et al., 2016; Kuo et al., 2017). For instance, Rudsberg et al. (2017) found that students learned from the argumentation skills they observed being exhibited by their peers during classroom debates, thus allowing for new perspectives to be considered during subsequent opportunities to provide evidence and reasoning to support their own arguments. A community of cooperation changes a student's identity in the academic realm; the idea of learning shifts from the sense that one must comprehend and remember chunks of information to the realization that, as a team, members may begin to work through and understand the purpose and significance of the newly presented information through investigative discourse (Farnsworth et al., 2016).

Cooperative structures offer the potential to disengage from groupwork models in which one member completes all the work tasks, while the other members benefit equally (Johnson & Johnson, 2009; Strebe, 2017). Rather, cooperation presents the potential to participate in a community of inquiry (Garrison, 2016). Students become more engaged in their investigative learning through active discourse, rather than maintaining a spectator role as new concepts are introduced by the instructor (Duran et al. 2019; Strebe, 2017). It has also been found that the accountability of each of the group members serves to cultivate an overall increase in motivation,

thus encouraging higher engagement (Tran, 2019). Additionally, it has been found that incorporating cooperative groups of three to five members in the academic setting is more effective for assimilating new content than individual learning (Gillies, 2016a). Garrison (2016) argues that humans are naturally equipped with the capacity to communicate with others and, correspondingly, possess the innate ability to share thoughts, feelings, and opinions; therefore, it is claimed, cooperative structures allow humans to embrace such native capabilities to uncover and learn more about humanity and the surrounding world.

**Promoting Equity through Cooperation.** Cooperative learning strategies present equitable opportunities for academic success among all students (Colton et al., 2016; Doporto & Rodríguez, 2016; Tan, 2017b). As explained by van Bunderen et al. (2018), when members of a team depend upon the efforts of one another to effectively accomplish shared goals, they tend to be more invested in ensuring the success of each of the other members by sharing resources, knowledge, and support. Some students may be at a disadvantage within a traditional learning setting due to varying learning styles, language barriers, academic gifts, or disabilities that may be present; alternatively, cooperative learning strategies tend to garner success because of the exceptionalities which exist among each of the participating students (Tan, 2017b). Research conducted by Tan (2017b) offers crucial insight regarding learners of different cultures. It was found that cooperative learning was more beneficial for diverse groups of students because the students tended to preside at the center of the process. Teachers, as the knowledge transmitters within a traditional classroom setting, often possess beliefs and customs that differ from those held by many of their students (Tan, 2017b). Cooperative learning, however, involves frequent discourse within the group, which allows for the diverse sets of beliefs, ideas, and perspectives of the various group members to be introduced and incorporated into the overall learning that

transpires – thus offering a more developed understanding of the topic (Rudsberg et al., 2017; Tan, 2017b).

**Cooperative Efforts in Academia.** During cooperative learning exercises, students often gain new insights from their peers which may foster the opportunity to make meaning of the content from a new and enlightened perspective (Rudsberg et al., 2017). When students examine information through a different lens, they gain the ability to analyze it through new thinking processes to ultimately “construct new understandings” (Guzmán & Payá, 2020, p. 3). This is evident in the results of many recent research studies (Amrullah, & Suwarjo, 2018; Erdogan, 2019; Loes et al., 2018; Raviv et al., 2019). The peer discourse associated with cooperative learning methods is instrumental in compelling students to approach topics in a more innovative and meaningful manner (Gillies, 2016a). Research has supported this notion, as many studies have found cooperative learning to be influential in the development of critical thinking skills among school-aged children (Amrullah & Suwarjo, 2018; Gillies, 2016a; Lee et al., 2016; Wati & Fatimah, 2016). The benefits of cooperative learning seem to exceed those of direct instruction, with various research studies concluding that students also tend to demonstrate an increase in academic performance (Foldnes, 2016; Gkloumpou & Germanos, 2020; Raviv et al., 2019), classroom-appropriate social skills (Camacho-Minuche et al., 2021; Strebe, 2017; Topping et al., 2017), academic motivation (Gillies, 2016a; Tran, 2019; Varvarigou, 2016), and self-confidence (Tirta et al., 2019; Nugreha et al., 2018; Supanc et al., 2017), as well as a decrease in academic and social anxiety (Eryilmaz & Cigdemoglu, 2019; Hilliard et al., 2020; Rad & Heidari, 2017) when engaging in cooperative classroom activities. Such literature greatly supports the positive effects of facilitating cooperative learning in academia.

**Importance of Structure in Cooperation.** Although cooperative learning presents a wide range of academic, social, and personal benefits, it would be unreasonable to place students in a group and expect for them to work cooperatively (Gillies, 2016a). Rather, students often struggle to engage in such a manner (Topping et al., 2017). Peer discourse, therefore, must be structured strategically to allow for such cooperation to appropriately transpire (Buchs et al., 2017; Gillies, 2019; Johnson & Johnson, 1999). To influence cooperative discourse, it is advantageous to begin by scheduling peer interactions, ensuring that the students within a group each have access to different chunks of the content being learned, and offering some type of incentive for sharing one's knowledge with the rest of the group (Bell & Hernandez, 2017). For cooperative learning to be effective, the group must experience interdependence – the understanding that the group cannot successfully reach its goals without the cooperation and efforts of each of its members (Gillies et al., 2016a; Jacobs & Renandya, 2019; Topping et al., 2017), much like the mentality of the members of a sports team (van Bunderen, 2018).

Cooperation among teams tends to transpire most productively when a structure for doing so is conceived in advance (Ghufron & Ermawati, 2018). Research conducted by Cecchini et al. (2020) examined high and low-structured cooperative activities; it was found that increased structure resulted in the most effective cooperation because students were prepared with specific expectations and routines to be followed. Student behaviors within the group setting can be more readily managed when a clear structure for the cooperative peer discourse is present (Veldman et al., 2020). A strategy that may be utilized by instructors to facilitate group cooperation is the implementation of collaborative scripts (Tan, 2018). Collaborative scripts provide a foundation for students to reference when determining how to engage with their peers during group activities; scripts can be particularly valuable to group members who may possess low

knowledge of the subject and are unsure of how to begin engaging with the content or their peers (Deiglmayr & Schalk, 2015). By making such a tool available to students, peer discourse and cooperation may be more likely to transpire as intended among members of the group (Vogel et al., 2017).

### **Incorporating Scripts for Critical Thinking**

Peer dialogue in the educational setting is only beneficial if it is productive towards the desired learning goals (Gillies, 2019). Collaborative scripts can serve as scaffolded frameworks to ensure rich and meaningful discussions transpire among groups of peers (Cáceres et al., 2018; Ludvigsen et al., 2016; van der Meij & Leemkuil, 2019). Recent research studies offer supporting evidence that the incorporation of scripts can lead to greater learning outcomes (Lee, 2018; Lin, 2020; Vogel et al., 2017). Many studies have reported significant results regarding increased critical thinking skills as a result of such structured peer discussions; however, much of this research has been conducted at the university level (Harney et al., 2017; Hidayati, 2017; Saputra et al., 2019), or in environments in which cooperative learning was not implemented (Eggert et al., 2017; Lee & Irving, 2018; Ramirez & Monterola, 2019; Tan, 2018). This research sought to fill a gap in the literature by investigating how the incorporation of collaborative scripts in a cooperative learning secondary science classroom impacts the cultivation of students' critical thinking skills. Theoretical frameworks were used to guide this inquiry; the proposal was that students would engage in modeling behaviors, as supported by Bandura's (1977) social learning theory, as they would practice, transfer, and cultivate a new set of skills, as supported by Vygotsky's (1978) sociocultural theory of cognitive development, through structured discourse, involving the participation of all members, as supported by Deutsch's (1949) social

interdependence theory, to meet the objective of engaging in the learning process in a more profound manner.

### ***The Value of Collaborative Scripts***

Strategic instructional scaffolding, which activates the ability to connect one's thinking from one set of concepts to the next, provides students the opportunity to realize their ZPDs (Erbil, 2020), as introduced by Vygotsky's (1978) sociocultural theory of cognitive development. Collaborative scripts serve as a scaffolding tool for students in this regard (Cáceres et al., 2018; Ludvigsen et al., 2016); students are guided to engage with the content in new and meaningful ways when they ask one another questions that elicit application of their learning to real-world settings, the creation and justification of claims from their understanding of the topics, critical analysis and the formulation of opinions regarding the claims of others, drawing of new conclusions, and the cultivation of solutions to various problems – along with many other possibilities (Marzano, 2017). Collaborative scripts provide students with a structure to formulate new connections to related topics through cooperative discussions, thus deepening understanding and offering an opportunity to engage in higher order thinking processes pertaining to the newly introduced content (Wang & Mu, 2017). As explained by Schwaighofer et al. (2017), scaffolding activities are also a vital component in terms of working memory, as they guide students to associate new concepts with previously formed schemata and present opportunities to establish connections to new and prior learning. Collaborative scripts offer students the time and structure necessary to scaffold their learning – to interpret the new information and construct meaning from it (Tan, 2018).

When guiding students in conversations in which scaffolding is the focus, it is crucial to ensure the patterns of discussion are structured accordingly (Marra et al., 2016). Collaborative

scripts direct the path of peer discourse among a group of students, which may encourage the manifestation of the intended cognitive processes regarding the topic of instruction (Chen & Chiu, 2016). The purpose of incorporating scripts in the educational setting is to introduce students to new ways of perceiving, discussing, and thinking about the content being learned; scripts are implemented as a temporary intervention meant to coach students on the collaborative skills that may assist in these domains as the scripts are gradually faded out (Schwaighofer et al., 2017). Future collaboration and thought processes among groups of students can be more meaningful, with a lessened need for facilitation (Marra et al., 2016). In fact, Vogel et al. (2017) observed a large effect size ( $d = 0.95$ ) for meaningful collaboration among students who had been exposed to the intervention of collaborative scripts. Chen and Chiu (2016) noted a statistically significant difference in metacognition – particularly analysis and evaluation – among fifth-grade mathematics students who engaged in the use of collaborative scripts when compared to those who did not use the scripts. Findings such as these support the overall purpose of utilizing collaborative scripts in the educational environment to support peer discourse and learning of academics or new skills.

### ***Structuring Scripts for Engagement***

The structure of collaborative scripts, in an academic setting, determine how students will engage with the content (Heimbuch et al., 2018; Lin, 2018; Stegmann et al., 2016; Tchounikine, 2016). However, it can be difficult to predict how students will interact with the scripts which they are provided (Ludvigsen et al., 2017; Tchounikine, 2016). To appropriate the scripts, as intended, it is theorized that students must possess the motivation to do so (Stegmann et al., 2016; Tchounikine, 2016). As explained by Tchounikine (2016), motivation of students is often related to an understanding of the learning goals associated with the scripts; for example, if the



students within a group are provided with a vague outline to develop a claim, argument, and counterargument collaboratively, they are much less likely to freely engage than if the script offers more detailed direction – with deconstructed components – such as: “first produce an individual definition of a list of concepts; then collaboratively write a few lines that relate or discriminate two concepts” (p. 352). Greater structure within the scripts can provide the scaffolding that guides student learning, as supported by Vygotsky’s (1978) theory, thus allowing for a more advanced understanding of the purpose and goals of the assignment, and, ultimately, increasing motivation to engage with one’s other group members (Stegmann et al., 2016; Tchounikine, 2016), as supported by Deutsch’s (1949) theory. How a script is structured will determine how students understand, internalize, and implement its contents to maximize learning outcomes (Stegmann et al., 2016).

Research conducted by Wang et al. (2017) found that students preferred scripts which entailed clear and structured guidance, as these scripts elicited less anxiety concerning collaborative expectations. Similarly, Heinonen et al. (2020) advocate for increased guidance within scripts to ensure the educational goals can be pursued and in the scaffolded path which is intended. When implementing scripts of varying structures, Heimbuch et al. (2018) found that the scripts which offered a higher level of guidance were most beneficial in terms of student engagement and learning. Additionally, Mende et al. (2017) noted that students with lower prior subject knowledge benefitted the most from the utilization of scripts in which greater guidance was present, thus offering additional insight into the significance of higher structure in scripts. For example, it was found that scripts with less structure afford students the opportunity of “getting the work done with the least possible effort” (Stegmann et al., 2016, p. 373). When incorporating a structure that offers the opportunity to scaffold one’s understanding of the

concepts, however, the educational goals become more apparent, as connections between old and new topics are made, and the original goal to exert minimal effort is replaced with the goal of learning (Tchounikine, 2016).

### ***Scripts Implementation in Academia***

Collaborative scripts deliver an essential foundation for groups of students to begin processing information and co-constructing meaningful ideas – through peer discourse – which may never have been established through individual thought (Deiglmayr & Schalk, 2015). A research study conducted by Näykki et al. (2017) found that the implementation of scripts fostered significant gains in students' academic collaborative skills. According to Popov et al. (2019), the use of scripts is beneficial in bridging cultural gaps among students, as the structured collaboration permits students to express and entertain various ideas, beliefs, and opinions from a multitude of perspectives, thus influencing students' thinking processes concerning the topics of discussion. Through self-reporting, students have even reported positive sentiments towards the structure and guidance offered by scripts during collaborative peer discourse in the classroom (Radkowsch et al., 2020; Tibi, 2018).

The incorporation of collaborative scripts among groups of students has offered many educational benefits, as noted throughout the literature, including gains in academic performance (Knight & Mercer, 2017; Rau et al., 2016; Wang & Mu, 2017), increased engagement and motivation (Lee, 2015; Radkowsch et al., 2020; van der Meij & Leemkuil, 2019; Wang et al., 2017), improved self-efficacy (Çeliker, 2021; Lin, 2020; Harney et al., 2017), and the cultivation of critical thinking skills (Eggert et al., 2017; Lee, 2018; Ramirez & Monterola, 2019). The structure of scripts promotes the accountability of all group members (Heinonen et al., 2020), as supported by Deutsch's (1949) social interdependence theory. The scaffolding of scripts

promotes learning in which new and old concepts may be connected to assist students in realizing their ZPDs, as supported by Vygotsky's (1978) sociocultural theory of cognitive development. The modeling of scripts among groups of peers is valuable in developing one's own collaborative skills – particularly as evidenced by instances in which scripts have been faded, and eventually removed, from instruction (Schwaighofer et al., 2017), as is supported by Bandura's (1977) social learning theory. In general, scripts can add significant value to the learning and collaborative processes within academic settings (Wang & Mu, 2017).

### **Current Literature and Research**

Many research studies have been conducted to investigate how the use of scripts may enhance collaborative discussions by evoking purposeful and profound dialogue; collaborative scripts have been found to be beneficial for students in that regard (Lee, 2018; Lin, 2020; Ludvigsen et al., 2016; Näykki et al., 2017; Olesova et al., 2016; Tan, 2018; van der Meij & Leemkuil, 2019; Vogel et al., 2017). With such supporting research, it is necessary to investigate how the use of collaborative scripts in a cooperative learning environment may increase students' critical thinking skills in the classroom. Research studies have been conducted to assess how collaborative scripts can be helpful at the university level (Harney et al., 2017; Hidayati, 2017; Saputra et al., 2019), but not at the secondary level in a cooperative learning environment. While much research exists pertaining to cooperative discussions and the development of critical thinking skills, the literature is lacking on effective techniques for guiding meaningful discussions that will cultivate the critical thinking skills of students at the secondary level. A study which aims to investigate how the use of collaborative scripts may impact the development of secondary students' critical thinking skills in a setting that employs cooperative learning

strategies can employ the theoretical frameworks of Vygotsky (1978), Bandura (1977), and Deutsch (1949) in an effort to fill that gap.

The collaborative scripts in this research study served to scaffold student thinking to higher cognitive levels so that an assessment of critical thinking skills could be made for the experimental group, as well as the control group that is not exposed to the collaborative scripts, pre-intervention and post-intervention among secondary science students. An examination of prior literature was extraordinarily valuable in determining how to proceed with the research study, as well as how it may expand upon the body of literature which already exists. Vygotsky's (1978) sociocultural theory of cognitive development, Bandura's (1977) social learning theory, and Deutsch's (1949) social interdependence theory each offer critical insight into social learning environments for children, such as how new concepts are acquired, how meaning is assigned to those concepts, and how various motivational aspects impact student engagement with groups of their peers. Prior literature that focuses on cooperative learning strategies provides a foundation for understanding how to structure scripts to promote interdependence among group members (Gillies, 2016b; Johnson & Johnson, 2009; 2018; Kuhn, 2018; 2019; Strebe, 2017; Supanc et al., 2017). Literature pertaining to collaborative scripts delivers insight into the types of script structures which may promote greater engagement (Radkowsch et al., 2020; Wang et al., 2017), academic performance (Knight & Mercer, 2017; Rau et al., 2016; Wang & Mu, 2017), and, ultimately, the development of critical thinking skills (Çeliker, 2021; Eggert et al., 2017; Lee, 2018; Ramirez & Monterola, 2019). The desire was for this research study to add new insight to the existing body of literature regarding the use of collaborative scripts in a cooperative learning secondary science setting and the development of critical thinking skills for that population of students.

## Summary

As mentioned throughout recent literature, rapid progressions of civilization within the 21st century justify an increased need for the development of critical thinking skills among humanity. Young people must be able to discern the difference between trustworthy and untrustworthy, as well as biased and unbiased, news reports – especially in an age in which ungoverned information is shared swiftly throughout social media. Furthermore, advancements in the scientific and technological fields have yielded opportunities for jobs in which analysis, reasoning, and problem-solving can take place. Many employers actively seek candidates with the possession of such skills. Engaging students in collaborative learning efforts has demonstrated that a cultivation of critical thinking skills can more readily transpire. Peer discourse has offered benefits such as perspective-sharing and probing of questions that lead to more profound thoughts about the content. The literature also informs that the way in which group work is typically designed is problematic. A lack of structure promotes less peer discourse. The peers with stronger academic backgrounds tend to assume greater responsibility, while those with weaker academic backgrounds may disengage altogether.

Cooperative learning methods, as supported by Deutsch's (1949) social interdependence theory, impose mutually dependent conditions in which the overall success of the group depends upon the active engagement and effort of each of the members involved. This interdependence creates a sense of accountability for each person. Many research studies have found cooperative learning to be effective for cultivating effective group dynamics in an educational setting. Students are confronted, however, with the requirement to interact with one another in a meaningful fashion. Such interactions, as the literature reports, do not transpire innately; they must be learned. The use of collaborative scripts to engage students in structured and thoughtful

peer discourse, as supported by Vygotsky's (1978) sociocultural theory of cognitive development and Bandura's (1977) social learning theory, has been demonstrated throughout current research to improve critical thinking skills.

## **CHAPTER THREE: METHODS**

### **Overview**

The purpose of this study was to investigate how the introduction of collaborative scripts into the cooperative learning of students in eight secondary science classrooms would impact the development of critical thinking skills. Chapter three presents the design of the research study as a quasi-experimental non-equivalent control-group design with the administration of a pretest and posttest. A justification for the design is presented, as supported by relevant literature. The research question and hypothesis align with the purpose of the study, as they each pertain to critical thinking skills in relation to the introduction of collaborative scripts in the educational setting described. The demographics of sample participants are conveyed. Instrumentation, as well as data collection procedures and the method for statistical analysis are also explained within this chapter.

### **Design**

This quantitative research study utilized a quasi-experimental non-equivalent control-group design. In this type of design, a control group and experimental group are established in which the participants of each group are not randomly assigned, and both groups are administered a pretest and posttest (Gall et al., 2007). This design was most appropriate for this study because it allowed for predetermined groups to be present within the secondary science classes being investigated. Since the critical thinking skills, as measured by CCT-X scores, of two different groups of students were analyzed in this research study, it was necessary to utilize a design in which a pretest and posttest could be administered. Doing so allows one to neutralize differences on the dependent variable of critical thinking skills prior to the intervention of collaborative scripts. To confidently measure the inferred effects of a treatment variable, the use

of a pretest and posttest allow for the dependent variable to be assessed (Gall et al., 2007).

Therefore, a quasi-experimental non-equivalent control-group design was most appropriate for this research.

The independent variable of this study was the type of instruction implemented. The experimental group utilized collaborative scripts, which can be defined as guided texts that foster productive talk about a topic among members of a group (Ludvigsen et al., 2016; Tan, 2018; Vogel et al., 2017). The dependent variable measured in this research study was critical thinking skills, as measured by scores on the Cornell Critical Thinking Test, Level X (CCT-X) (Demirci, 2017; Ennis et al., 2005; Erdogan, 2019; Yin & Fitzgerald, 2017). The covariate was pretest scores on critical thinking skills, as measured by the CCT-X. For this research study, critical thinking skills are defined as the skills which allow one to assess a problem or situation based on the evidence available and provide an argument with effective reasoning (Ennis & Millman, 1985).

### **Research Question**

The research question for this study is:

**RQ1:** Is there a significant difference in critical thinking skills, as measured by the CCT-X, for secondary science students who engage in cooperative learning with scripts and those who engage in cooperative learning without scripts while controlling for pretest scores?

### **Hypothesis**

The null hypothesis for this study is:

**H<sub>0</sub>1:** There is no significant difference in critical thinking skills, as measured by the CCT-X, for secondary science students who engage in cooperative learning with scripts and those who engage in cooperative learning without scripts while controlling for pretest scores.



## **Participants and Setting**

The participants for this study were drawn via convenience sampling from a public secondary school in a northeastern state. Students are enrolled in this school from many areas of the state: urban, suburban, and rural. There are 523 students enrolled – 82% of which qualify for free or reduced lunch. The school is similar to other secondary schools in the state in terms of academic curricula. The percentage of college-bound seniors is comparable to that of other schools in the area. Project-based learning with peer cooperation is a norm for instructional pedagogy throughout all classrooms. For this study, the participants were drawn from eight sections of the ninth grade integrated science course during the spring semester of the 2020-2021 school year.

## **Research Sample**

Convenience sampling was employed, as this study focused on a population of ninth grade science students who work collaboratively within a classroom environment. Due to the Coronavirus pandemic, most schools in the state have opted to engage in virtual or hybrid learning environments for much of the 2020-2021 school year. The school in which the research will take place is one of the only schools to participate in complete face-to-face learning. There are eight ninth grade science sections to choose from at the school and they were chosen because science is a subject which quite often requires critical thought processes, such as those which pertain to inductive exploration and collection and analysis of data (Dowd et al., 2018). Also, students in the ninth grade are new to the school and have not yet been exposed to the school's higher order instructional protocols. Four sections of the eight science classes served as the control group, while the other four sections served as the experimental group. Therefore, the groups of participants were naturally occurring, rather than randomly assigned. The study was

introduced to students during a classroom visit, and assent was obtained via student signatures. Opt-out forms with all information regarding the study were mailed to the households of each student for the parents or guardians to read. The study and its importance were explained in each instance.

In the overall sample, 171 participants were included, which meets the requirements for a medium effect size for an analysis of covariance at a statistical power of .7 and alpha level of .05 (Gall et al., 2007). Other researchers have used similarly sized samples to test the effects of an intervention on the development of critical thinking skills (Fung et al., 2016; Kusumoto, 2018; Stephenson et al., 2019). The sample participants for this research study are comprised of 55 (32.2%) females and 116 (67.8%) males, all aged 14-15 years old. Of the 171 students in the sample, 56 (32.7%) are identified as requiring special education services, while 115 (67.3%) are considered to be among the general education population. The sample includes 59 (34.5%) African American students, 3 (1.7%) Asian students, 36 (21.0%) Hispanic students, 2 (1.2%) students of the Pacific Islands, 69 (40.4%) White students, and 2 (1.2%) students of another race. Descriptive statistics for gender and race can be found in Table 1.

Table 1.

*Descriptive Statistics for Demographics of Sample*

Participant Demographics	<i>n</i>	%
<b>Gender</b>		
Male	116	67.8
Female	55	32.2
<b>Race</b>		
African American	59	34.5
Asian	3	1.7
Hispanic	36	21.0
Pacific Islander	2	1.2
White	69	40.4
Other Races	2	1.2

*N* = 171

**Demographics of Groups**

At this school, there are eight sections of the ninth grade integrated science course for the 2020-2021 school year. These are classes which meet twice a week for 90-minute periods. Four sections of the course collectively served as the control group, while the other four collectively served as the experimental group. Both groups are heterogeneous in terms of enrollment of general education and special education students, and both consist of students between the ages of 14-15. The groups are comparable in terms of classification of gender and race. The control group consists of 82 students with 56 (68.3%) males and 26 (31.7%) females. The experimental group consists of 89 students with 60 (67.4%) males and 29 (32.6%) females. Descriptive statistics regarding gender for each group can be found in Table 2.

Table 2.

*Descriptive Statistics for Gender*

Gender by Group	Gender	<i>N</i>	%
Control Group	Male	56	68.3
	Female	26	31.7
	Total	82	48.0
Experimental Group	Male	60	67.4
	Female	29	32.6
	Total	89	52.0

The control group consists of 27 (33.0%) African American students, 2 (2.4%) Asian students, 21 (25.6%) Hispanic students, 0 (0.0%) students of the Pacific Islands, 31 (37.8%) White students, and 1 (1.2%) student of another race. The experimental group consists of 32 (36.0%) African American students, 1 (1.1%) Asian student, 15 (16.9%) Hispanic students, 2 (2.2%) students of the Pacific Islands, 38 (42.7%) White students, and 1 (1.1%) student of another race. Descriptive statistics regarding race for each group can be observed in Table 3.

Table 3.

*Descriptive Statistics for Race*

Race by Group	Race	<i>N</i>	%
Control Group	African American	27	33.0
	Asian	2	2.4
	Hispanic	21	25.6
	Pacific Islander	0	0.0
	White	31	37.8
	Other Race	1	1.2
	Total	82	48.0
Experimental Group	African American	32	36.0
	Asian	1	1.1
	Hispanic	15	16.9
	Pacific Islander	2	2.2
	White	38	42.7
	Other Race	1	1.1
	Total	89	52.0

Each class section was assigned to represent either even or odd numbers, and an online random number generator was used to determine which class sections would be assigned to the control group and which class sections would be assigned to the experimental group, depending on whether the generated number was even or odd. The generated number was the factor which determined the experimental group. By default, the other classes were determined to serve as the control group. Since the generated number was 21 – an odd number – the odd period classes,

which are periods 1, 3, 5, and 7, were assigned to the experimental group. The even period classes – periods 2, 4, 6, and 8 – were assigned to the control group.

### **Instrumentation**

For this research study, the dependent variable was critical thinking skills, and was measured through the administration of a pretest and posttest. The instrument used to do so is called the Cornell Critical Thinking Test, Level X (CCT-X). This instrument was first developed by Ennis and Millman (1985); two versions of the test were constructed – the Level X and Level Z, and each test is appropriate for a different age range of individuals. The Level X instrument was the most appropriate choice for the population in this research study, as it is designed to be administered to students between 5th and 12th grade. Critical thinking skills are described by Ennis (1989) as "reasonable and reflective thinking which focuses on what one believes in or what to do" (p. 4). Murphy et al. (2018), highlight subdivisions of critical thinking, such as engagement in inductive and deductive reasoning, evaluating evidence, and questioning information, which are repeatedly reflected throughout the CCT-X assessment items (Ennis et al., 2005).

The CCT-X was constructed to evaluate one's ability to think critically about a variety of problems. It consists of 76 multiple-choice items which require students to synthesize and analyze information from a passage to draw the best conclusion from the evidence gathered. There are three possible answers to choose from: yes, no, and maybe. These responses refer to how true the statement about a passage is – it must be true, it must not be true, or it could be true. There is only one correct answer for each item, and each is worth one point – the sum of which will fall in the range of 0-76. The lowest possible score is 0, while the highest possible score is 76; lower scores indicate the presence of lower critical thinking skills and higher scores indicate

the presence of higher critical thinking skills (Ennis & Millman, 1985). There are four reading passages, which are referred to within in the test booklet and administration manual as sections. Each of these reading passages has numerous test questions associated with it, and the test, in its entirety, is intended to be delivered throughout one 50-minute time period (Ennis et al., 2005).

Construct validity for the CCT-X was determined by whether one or two of the five identified skills for critical thinking were addressed. These five constructs are induction, deduction, making assumptions, making observations, and questioning the credibility of sources. Of the test questions, 25 pertain to induction, 24 pertain to deduction, 10 pertain to making assumptions, 24 pertain to making observations, and 24 pertain to questioning the credibility of sources; several of the questions were listed under more than one category (Ennis et al., 2005); see Table 4. According to Yin and Fitzgerald (2017), a team of educational professionals verified the construct validity of the tool, as the questions pertaining to the five constructs were representative of what an educator would look for regarding students' answers in the academic setting to assess critical thinking. Processes of induction involve forming conclusions or solutions from the evidence presented, deduction involves being presented with the conclusion and seeking supporting evidence, making assumptions involves predicting from prior evidence, making observations involves identifying critical and/or supporting information, and questioning the credibility of sources involves using supporting evidence to either justify or reject a claim that is made (Ennis et al. 1985).

Table 4.

*Measured Constructs on CCT-X*

Constructs	<i>n</i>	%
Induction	25	25.3
Deduction	24	28.2
Making Assumptions	10	15.5
Making Observations	24	9.9
Questioning Credibility of Sources	24	21.1

*N* = 76

The purpose of utilizing the CCT-X in this research study was to measure the critical thinking skills of students in a secondary science classroom after those in the experimental group were exposed to the intervention of collaborative scripts; this allowed for an analysis to be conducted to determine if a significant difference could be found in their posttest scores compared to those of the students in the control group who were not exposed to the intervention of collaborative scripts – all while controlling for pretest scores. Permission to use the instrument was obtained; see Appendix A. The CCT-X was chosen because it has been used in many research studies in which the critical thinking skills of students were measured (Bigozzi et al., 2018; Erdogan, 2019; Hand et al., 2018). Erdogan (2019) measured the critical thinking skills of secondary-level students using the CCT-X as the instrument of measurement. The CCT-X was used as a pretest and posttest surrounding an intervention of reflective thinking strategies. A significant difference in scores was found to be in favor of the experimental group, offering support that reflective thinking strategies result in greater critical thinking skills. Bigozzi et al. (2018) found greater critical thinking skills, as measured by the CCT-X, among secondary students exposed to the instructional method of guided constructivist learning. The researchers



performed further analysis, however, by examining the scores of the various critical thinking constructs measured by the test.

Estimates of the reliability for the CCT-X, according to Ennis et al. (1985), range between .49 and .87. However, researchers throughout the current body of literature consistently report reliability scores between .70 and .90, (Bati & Kaptan, 2015; Bigozzi et al., 2018; Demirci, 2017; Erdogan, 2019; Heidari, 2020; Intarit, 2017; Kettler, 2014; Kwan & Wong, 2015; Ling & Loh, 2020; Muhammad et al., 2015; Walker & Kettler, 2020; Yin & Fitzgerald, 2017). A computer and paper version are available for the CCT-X (Ennis et al., 2005). For this study, the researcher chose to administer the paper version of the test. The pretest and posttest were both administered to the participants of each section during regularly scheduled class time. Guidelines state that students require approximately 50 minutes to complete the test (Ennis et al. 2005); therefore, the participants in this study were permitted the same time frame. Participants earned one point for each correct answer and no points for incorrect answers.

### **Procedures**

Permission was obtained from Liberty University's Institutional Review Board (IRB) to conduct the study; see Appendix B for IRB approval letter. Permission to conduct research at the school was acquired from the head of school. Parents and guardians of students were sent an email through the school's mass emailing system explaining that a research opportunity would be taking place in the freshman science classes and an opt-out form with further details would be mailed to their households within two days. An opt-out form was then sent to the parents/guardians of all students participating in the study. Each original envelope contained a return envelope with a printed address, as well as prepaid postage. Instructions were included to return the signed opt-out form – if the parent/guardian so wished – within five business days of

receipt. It was also articulated that, following this allotted timeframe, the opportunity would still be available to decline/revoke permission at any time by emailing the researcher or contacting the school. An additional form that is identical to the opt-out form – without the signature line – was included in the envelope to ensure parents/guardians would always have access to the information regarding the study. Students of the control and experimental groups, which consisted of all the ninth grade integrated science class sections, were advised of the purpose, procedures, and importance of the study during a regularly-scheduled class period. A script was followed by the researcher to ensure students of all class sections received the same explanation; see Appendix C for the explanatory script. Absent students were met with upon return, and the researcher read from the script again. An untimed question-and-answer session was conducted after the explanation was made. All students were encouraged to ask any additional questions they may consider later via email. It was emphasized that all questions were welcome, and that students were permitted to leave the study at any time without penalty.

All students were asked to sign an assent form if they were willing to participate in the study. The students who were unsure of how to proceed were asked to take additional time to think about it and write down any questions or concerns they think of regarding participation in the study. They were asked to provide a final answer within three class days. One student requested not to be included in the research study, which brought the anticipated sample size of 172 to 171. As had been previously explained, this student was still directed to participate in the class activities, as would typically be expected in the classroom environment, but no data was collected regarding his performance. He did take the pretest but removed himself from the study before taking the posttest. Therefore, his pretest was not counted. Rather, he was provided with an alternative assignment from his teacher during the time the rest of the class took the pretest

and posttest. Though several clarifying questions were asked, no opt-out forms were returned from parents or guardians.

### **Group Assignments**

Each of the eight integrated science sections were assigned to represent either even or odd numbers, and an online random number generator was used to determine which class sections were to be assigned to the control group and which class sections were to be assigned to the experimental group, depending on whether the generated number was even or odd. The generated number was the factor that determined the experimental group. The control group was then determined accordingly. Since small groups were also needed for the cooperative learning aspect, smaller groups were created within the control and experimental groups by using an online random group assignment tool.

### **Pilot Study**

A short pilot study, without a pretest and posttest, was conducted on a miniature learning unit to ensure the participants who were in the experimental group understood the use of the scripts and how to follow them. The lesson was introduced to the participants in the way a lesson typically would be introduced. The instructor began the lesson with a “hook,” as is typical of an introduction to a new lesson. Since the participants had previously become accustomed to engaging in cooperative groupwork with project-based learning prior to the lesson introduction, the phenomenon to be studied was introduced, without any further information – as would be characteristic in each classroom of the school. Participants were instructed to read the questions from the scripts verbatim to engage in the peer discourse that would prompt them to explore the phenomena in various ways; see Appendix D for the collaborative scripts. Each participant was also instructed to utilize the script a minimum of three times throughout the miniature lesson.

The scripts provided to students were modeled from the examples and insight gained from prior research studies and informative literature (Harney et al., 2017; Knight & Mercer, 2017; Marra et al., 2016; Ramirez & Monterola, 2019; Stegmann et al., 2016; Tan, 2018; Tchounikine, 2016).

Participants were redirected when not using the scripts or not using them appropriately; see Appendix E for the instructions provided to participants regarding how to utilize the scripts. This pilot study ensured that each student understood how to use the scripts, and it offered an opportunity to answer any questions about the use of the scripts, as well as clarify any misconceptions.

### **Research Study**

At the start of the research study, participants were provided 50 minutes from their regularly scheduled science class period to take the CCT-X as a pretest. Instructions, as written in the administrator's manual by Ennis et al. (2005), were delivered verbatim to the participants. The test was delivered on paper. Each student was provided with a test booklet, scantron sheet, and #2 pencil. No additional materials were made available to the participants during the period of testing. The new learning unit, during which data was collected, did not begin until one week following the pretest administration to allow time for the participants who were originally absent to take the test.

To protect participants' privacy, participants were asked to generate their own code names by writing their favorite color, favorite animal, and last four digits of their phone number on the scantron sheets when taking the pre-test and post-test. An example of a code name would be BlueShark5678. The reason for utilizing a code name with specific criteria – rather than one chosen at random – was to ensure the code name would be easier to remember for the participants throughout the three-week time period. The data from the scantron sheets was

recorded and organized in a spreadsheet with student code names. To maintain confidentiality, pre-test and post-test scores were attached to the code names chosen by the participants.

The learning unit, with phenomena, was introduced to the participants; see Appendix F for lesson plan. Once participants were introduced to the lesson phenomena, they were instructed to begin work. The control group was instructed to begin investigating the phenomena via discussions among peers in their groups using the provided scaffolded learning materials. The experimental group was instructed similarly, except they were also prompted to use their scripts to engage in discussions. The previously conducted pilot study ensured that each student understood how to appropriately use the scripts. Students were not required to use the scripts at all times throughout the discussions, but it was conveyed that each student should refer to and use the scripts at least three times per class period during the course of the project discussions. During this time, the researcher walked around the room to monitor and listen to the discussions taking place among groups of students. A checklist was used to ensure all students (in each occupied seat) utilized the scripts as intended – which was a minimum of three times per class period. No student names or identifiers were present on the checklist – just the seat of the student. The purpose of the checklist was to simply inform the researcher of which seated students required gentle reminders or prompts if the scripts were not being utilized as intended; see Appendix G for checklist.

Each class day, participants continued working from clues discovered and ideas generated during the previous class. Periodically, the class would pause to engage in a whole-group discussion about the learning, as would typically transpire. This practice was conducted in a consistent manner across the experimental and control groups. The learning unit took place over a period of three weeks. Immediately following the conclusion of the unit, the CCT-X was

administered as a posttest in the same manner as the pretest. Responses for both the pretest and posttest were entered into a spreadsheet and stored securely on the researcher's password-protected computer.

### **Data Analysis**

A one-way Analysis of Covariance (ANCOVA) was performed to test the null hypothesis that there would be no significant difference in critical thinking skills, as measured by the CCT-X, for secondary science students who engage in cooperative learning with scripts and those who do so without scripts while controlling for pretest scores. The ANCOVA statistical procedure was chosen because it can test for significance while controlling for the pretest covariate (Gall et al., 2007; Warner, 2013). Additionally, the ANCOVA allows for an independent variable in which two or more groups are present, as would be required for a research study that examines a control and experimental group to test for statistical differences on the dependent variable (Gall et al., 2007). With an ANCOVA, it is also possible to measure the dependent variable of CCT-X post-test scores, as well as the covariate of CCT-X pre-test scores, on a continuous interval scale (Gall et al., 2007).

Before proceeding with the ANCOVA testing, however, data screening was conducted to ensure no data points were missing and no inaccuracies were present. Box and whiskers plots were constructed (Green & Salkind, 2017); observations of the box and whiskers plots indicated no extreme outliers in the data. It was also necessary to ensure some assumptions were met. Due to the sample size, a Kolmogorov-Smirnov Test was conducted to check the normality of the distribution (Green & Salkind, 2017), and the results indicated the assumption was met. The second assumption concerning linearity of the data was also met; scatter plots were constructed for both the experimental and control groups between the pre-test and post-test scores. A linear

relationship was evident in each scatterplot. Additionally, the scatter plots were examined to address the third assumption of bivariate normal distribution; this assumption was met, as evidenced by a classic cigar shape formed by the data points (Warner, 2013). The fourth assumption of homogeneity of slopes was investigated by conducting tests of between-subjects effects to identify interactions (Green & Salkind, 2017). The fifth assumption of equal variance was also met (Green & Salkind, 2017). Levene's Test of Equality of Error Variance indicated that homogeneity was met, with the assumption that the variance was equal (Warner, 2013). Once the data screening was conducted and all assumptions were met, ANCOVA testing was performed with an alpha level of .05. Partial eta squared is the convention that was used to measure effect size, and it was interpreted as Cohen's *d* (Warner, 2013).

## CHAPTER FOUR: FINDINGS

### Overview

This chapter incorporates the research study's findings following the collection of data. The research question and null hypothesis which guided this study are revisited. Descriptive statistics are mentioned to provide an overview of the collected pretest and posttest scores for both the control and experimental groups. The results of the data analysis are discussed, including all data screening and assumptions testing that took place prior to conducting the one-way analysis of covariance (ANCOVA). Finally, this chapter reports on the statistical significance of the posttest scores between the control and experimental groups of participants, while controlling for pretest scores.

### Research Question

The research question for this study is:

**RQ1:** Is there a significant difference in critical thinking skills, as measured by the CCT-X, for secondary science students who engage in cooperative learning with scripts and those who engage in cooperative learning without scripts while controlling for pretest scores?

### Null Hypothesis

The null hypothesis for this study is:

**H<sub>0</sub>1:** There is no significant difference in critical thinking skills, as measured by the CCT-X, for secondary science students who engage in cooperative learning with scripts and those who engage in cooperative learning without scripts while controlling for pretest scores.

### Descriptive Statistics

This research study examined how the introduction of collaborative scripts into the cooperative learning of students in eight secondary science classrooms would impact the



development of critical thinking skills. The data collected in this study were derived from the Cornell Critical Thinking Test (CCT-X), which was administered to all participants as a pretest and posttest. The sample of participants in this study was comprised of 171 ninth grade science students within a cooperative learning environment. It was anticipated that 172 students would participate, but one student chose not to participate toward the end of the study when the posttest was administered. The control group consisted of 82 participants, while the experimental group consisted of 89 participants. Potential scores on the CCT-X range between 0 and 76, with 76 indicating the highest score for critical thinking skills. See Table 5 for descriptive statistics.

Table 5.

*Descriptive Statistics for CCT-X Scores*

Test	Group	<i>Min</i>	<i>Max</i>	<i>M</i>	<i>SD</i>	<i>N</i>
Pretest	Control	6	67	32.83	13.34	82
	Experimental	8	65	33.36	13.95	89
	Total	6	67	33.11	13.62	171
Posttest	Control	7	68	34.63	14.31	82
	Experimental	10	72	35.98	14.54	89
	Total	7	72	35.33	14.41	171

## Results

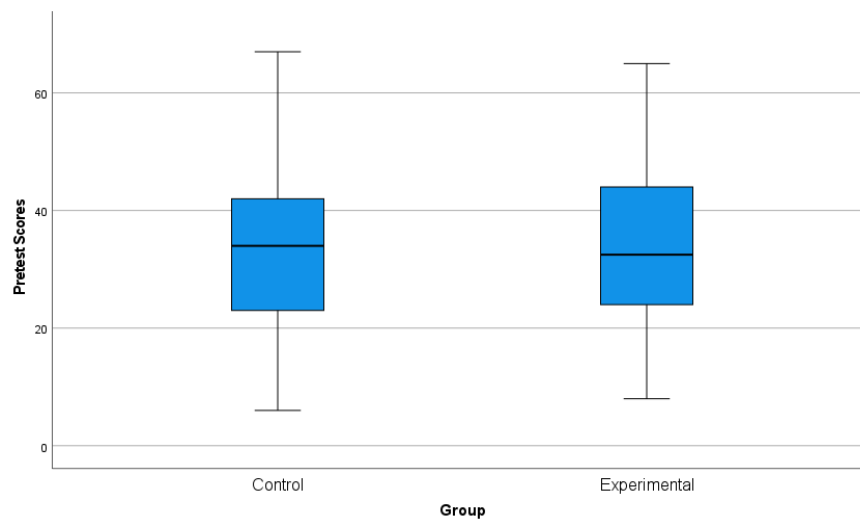
Data analysis for this research study, which utilized a quasi-experimental non-equivalent control-group design, transpired in a sequential manner – beginning with data screening and assumptions testing. After the prerequisite conditions were satisfied, a one-way ANCOVA was conducted to assess statistical significance of the independent variable on the dependent variable while controlling for the covariate of pretest scores. This allowed for a determination to be made

to either reject or fail to reject the null hypothesis. All steps of statistical analysis were completed while using the Statistical Package for the Social Sciences (SPSS) software.

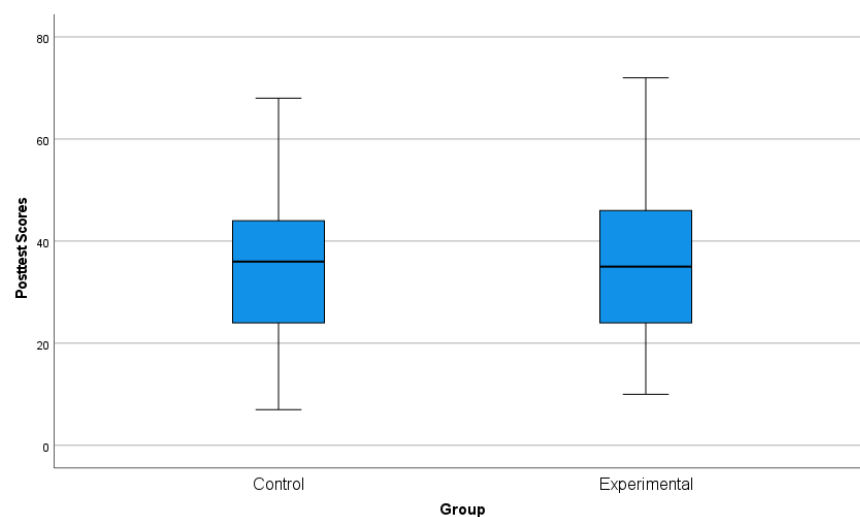
### Data Screening

Data screening was conducted to ensure no data points were missing and no inaccuracies were present. Box and whiskers plots were constructed (Green & Salkind, 2017); see Figure 1 and Figure 2. Observations of the box and whiskers plots indicated no extreme outliers in the data.

*Figure 1.* Pretest CCT-X scores for control and experimental groups.



*Figure 2.* Posttest CCT-X scores for control and experimental groups.



## Assumptions Testing

Assumptions testing was also performed before proceeding with data analysis. Due to the sample size, a Kolmogorov-Smirnov Test was conducted to check the normality of the distribution (Green & Salkind, 2017), and the results indicated the assumption was met; see Table 6.

Table 6.

### *Kolmogorov-Smirnov Normality Test for CCT-X Scores*

Test	Group	Kolmogorov-Smirnov	<i>df</i>	Significance
Pretest	Control	0.068	82	0.200*
	Experimental	0.074	89	0.200*
Posttest	Control	0.057	82	0.200*
	Experimental	0.076	89	0.200*

\*. This is a lower bound of the true significance.

The second assumption concerning linearity of the data was also met; scatter plots were constructed for both the experimental and control groups between the pre-test and post-test scores. A linear relationship was evident in each scatterplot. Additionally, the scatter plots were examined to address the third assumption of bivariate normal distribution; this assumption was met, as evidenced by a classic cigar shape formed by the data points (Warner, 2013). See Figure 3 and Figure 4.

Figure 3. Control group pretest and posttest scores.

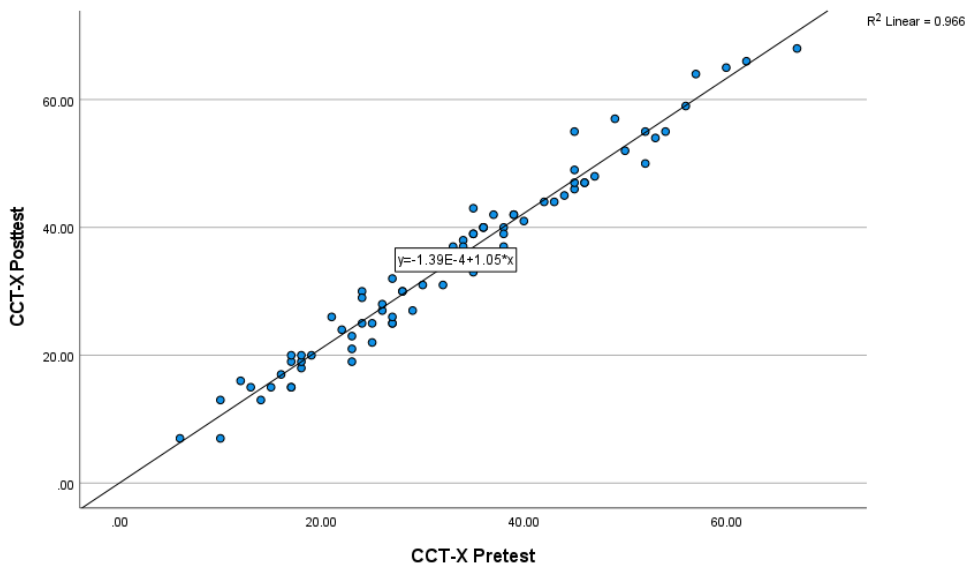
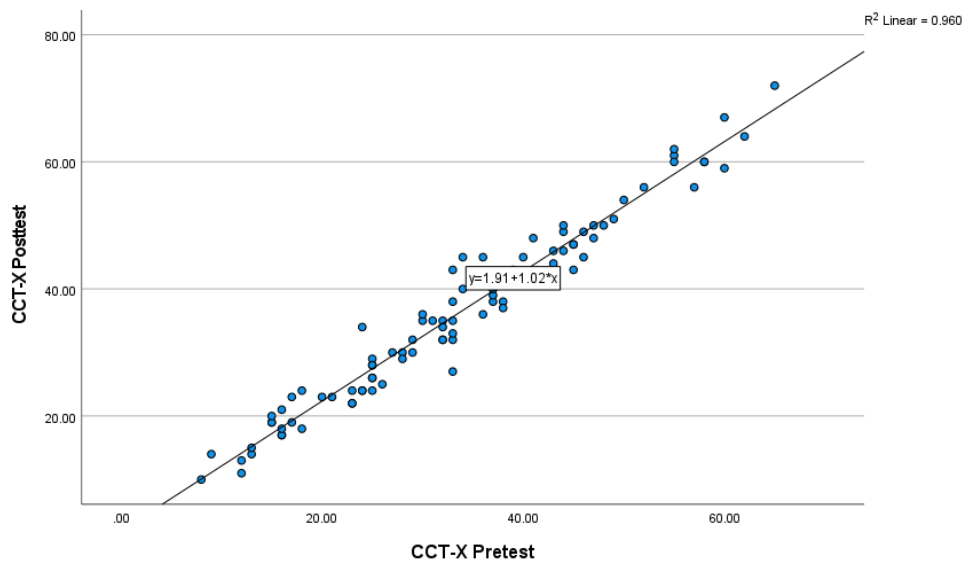


Figure 4. Experimental group pretest and posttest scores.



The fourth assumption of homogeneity of slopes was investigated by conducting tests of between-subjects effects to identify interactions (Green & Salkind, 2017); see Table 7. The significance of interaction between terms was 0.285, thus, the assumption is tenable.

Table 7.

*Tests of Between-Subjects Effects.*

Source	Type III Sum of Squares	<i>df</i>	Mean Square	<i>F</i>	Sig.
Corrected Model	33983.371 <sup>a</sup>	3	11327.790	1461.222	.000
Intercept	22.373	1	22.373	2.886	.091
Group	22.379	1	22.379	2.887	.091
Pretest Scores	33739.255	1	33739.255	4352.178	.000
Group*Pretest	8.933	1	8.933	1.152	.285
Error	1294.629	167	7.752		
Total	248762.000	171			
Corrected Total	35278.000	170			

a. R Squared = .963 (Adjusted R Squared = .963)

The fifth assumption of equal variance was also met (Green & Salkind, 2017). Levene's Test of Equality of Error Variance indicated that variance was equal across groups (Warner, 2013); see Table 8.

Table 8.

*Levene's Test of Equality of Error Variance*

<i>F</i>	<i>df1</i>	<i>df2</i>	Significance
0.477	1	169	0.491

**One-Way ANCOVA Analysis**

An ANCOVA was used to test the null hypothesis regarding posttest CCT-X scores after receiving two different types of instruction – that which incorporated collaborative scripts and

that which did not. The null hypothesis was not rejected at a 95% confidence level where  $F(1, 168) = 3.46, p = .064, \eta_p^2 = .020$ . The effect size was small (Warner, 2013). There was not a significant difference between the experimental group which received the collaborative scripts intervention ( $M = 36.33, S.E. = 14.78$ ) and the control group which did not ( $M = 34.63, S.E. = 14.31$ ).

## **CHAPTER FIVE: CONCLUSIONS**

### **Overview**

This chapter discusses how the research findings from this study relate to the existing body of literature. The theoretical frameworks of Vygotsky (1978), Bandura (1977), and Deutsch (1949) are revisited and discussed in terms of the research question and null hypothesis for this study. Implications of this study on the field of education are mentioned, as well as the limitations which may have threatened internal and external validity throughout the study. Chapter Five concludes with recommendations for future research which may build upon the body of literature pertaining to how collaborative scripts might be implemented in the secondary cooperative learning environment to guide peer discourse and cultivate the development of critical thinking skills among students.

### **Discussion**

The purpose of this research study was to investigate how the use of collaborative scripts can impact the development of secondary students' critical thinking skills in the science classroom. To do so, eight classes of enrolled secondary science students at a school in a northeastern state were administered the Cornell Critical Thinking Test, Level X (CCT-X) as a pre-assessment and post-assessment surrounding the intervention of collaborative scripts (Ennis et al., 2005). The independent variable in this study was the type of instruction implemented, and it was established as an experimental and control group. The experimental group utilized collaborative scripts, which can be defined as guided texts that foster productive talk about a topic among members of a group (Furberg, 2016; Ludvigsen et al., 2016; Tan, 2018; Vogel et al., 2017). The dependent variable measured in this research study was critical thinking skills, as measured by scores on the CCT-X (Demirci, 2017; Ennis et al., 2005; Erdogan, 2019; Yin &

Fitzgerald, 2017). The covariate was pretest scores for critical thinking skills, as measured by the CCT-X.

The research question asked if a significant difference in critical thinking skills would be present for the students exposed to collaborative scripts compared to those who were not, and the null hypothesis stated that there would not be a significant difference. ANCOVA testing was employed to compare the critical thinking skills of both groups of students, as measured by the CCT-X posttest, while controlling for CCT-X pretest scores (Warner, 2013). The results of this research study were not statistically significant ( $p = .064$ ), and the effect size was considered to be small (Warner, 2013); therefore, the null hypothesis was not rejected. A statistically significant difference was not present in CCT-X posttest scores between the control and experimental groups of students while controlling for CCT-X pretest scores.

### **Theoretical Frameworks**

The supporting theoretical frameworks for this research study all emphasize growth in a social context (Bandura, 1977; Deutsch, 1949; Vygotsky, 1978), and each of these theories have implications for the educational setting (Gutek, 2011). Collaborative scripts are used by groups of students in the classroom, which is considered to be a social setting (Tchounikine, 2016). The current research study examined how the use of collaborative scripts in a cooperative learning environment might structure the peer discourse among groups of students to lead their learning in a direction that would examine various ideas and questions to promote the use of critical thinking skills. The scripts utilized by participants in this research study were intended to serve as the invisible peer, as Gredler (2012) describes, to scaffold the type of learning that activates higher order thinking processes (Bloom 1956) to assist students in achieving their zones of proximal development (ZPD) (Vygotsky, 1978) for critical thinking skills.



Vygotsky's (1978) sociocultural theory of cognitive development states children acquire new information when provided appropriately scaffolded learning opportunities from a more knowledgeable peer; these scaffolds encourage connections to be made between topics, thus allowing for new learning to transpire. The ZPD is the gap in knowledge a child may fill when offered guidance from a more knowledgeable peer in comparison to the learning that may ensue without the presence of such guidance (Vygotsky, 1978). In this research study, the collaborative scripts functioned as the scaffolded instructional tool intended to guide students in realizing their ZPDs. Though growth between pretest and posttest scores was greater for the experimental group than the control group in this research study, it was not a statistically significant difference. The argument cannot be made that the collaborative script scaffolds assisted students in achieving their ZPDs towards greater critical thinking skills. Therefore, this research study does not offer strong support for Vygotsky's (1978) sociocultural theory of cognitive development.

Bandura's (1977) social learning theory states that children learn new behaviors by watching those behaviors being modeled by others; the consequences of those modeled behaviors determine the likelihood of being repeated by the observer. The collaborative scripts in this research study were used by the participants in the experimental group. Students worked in groups of three or four, and it was anticipated that as members of each group utilized the scripts during the lesson, they would be exhibiting how to use the scripts to guide peer discourse, thus promoting more appropriate and frequent use of the scripts by peers – and reinforcing their use. While this factor was not directly measured in the current research study, it did appear that the use of scripts did become more frequently used throughout the period of the intervention. There were no obvious indications as to what led to the increased use; therefore, no claim is being made regarding the cause.

Deutsch's (1949) social interdependence theory originally focused on the industrial setting, and it referenced the motivation of team members when peer accountability is present. Johnson and Johnson (1999) applied the same concept to the academic setting; in such an instance, the learning of new material is the goal to be achieved, as students work cooperatively through discussions and combined efforts to accomplish the desired learning objectives. The current research study was conducted in a school which attempts to provide a cooperative learning environment for students. The issue with cooperative learning is that children often do not know how to work cooperatively with one another; it is not an innate skill for most people (Gillies, 2016a; Topping et al., 2017). Collaborative scripts offer structure that can guide the discussions among groups of students (Heimbuch, et al., 2018; Heinonen et al., 2020; Mende et al., 2017). While this research study did incorporate collaborative scripts, the level of structure provided to the peer discourse as a result of using the scripts was not directly measured.

Vygotsky's (1978) sociocultural theory of cognitive development, Bandura's (1977) social learning theory, and Deutsch's (1949) social interdependence theory each offer substantial support to the topic of implementing collaborative scripts in a cooperative learning environment to cultivate critical thinking skills among students. Structured peer discourse serves as a guiding scaffold, as supported by Vygotsky's theory (Gredler, 2012). As students work through these new thinking processes with the content being discussed, the opportunity for academically stronger peers to model effective use of the scripts is presented, thus allowing the student group setting to be one in which new behaviors may be learned, as supported by Bandura's (1977) theory. As students work cooperatively, they become dependent upon one another to work through different aspects of the content as they work through their scripts to pose new ideas and questions to be pursued, as supported by Deutsch's (1949) theory. These theoretical frameworks

each offered support for the context of the current research study. However, with a focused research question and lack of statistical significance to confidently reject the null hypothesis, this research study is unable to offer substantial support in return.

### **Relating to Literature**

Many articles and research studies report on how scripts may be used to successfully enhance collaborative discussions among students by evoking purposeful and profound dialogue (Lee, 2018; Lin, 2020; Ludvigsen et al., 2016; Näykki et al., 2017; Olesova et al., 2016; Tan, 2018; van der Meij & Leemkuil, 2019; Vogel et al., 2017). Such a wide array of literature offered inspiration to investigate how the use of collaborative scripts in a cooperative learning environment may increase students' critical thinking skills in the secondary science classroom – a combined population and setting which is lacking throughout the literature. The findings of this research study did not support earlier findings from similar research studies, however. In the data collected from this study, a greater improvement can be seen from pretest to posttest in the experimental group when compared to the control group, but not to a degree which would be statistically significant.

Many of these research studies have been conducted at the postsecondary level (Deiglmayr & Schalk, 2015; Harney et al., 2017; Heimbuch et al., 2018; Lin, 2020; Mende et al., 2017; Näykki et al., 2017; Saputra et al., 2019; Schwaighofer et al., 2017; Wang et al., 2017), which involves a population of participants that differ in many ways – including their cognitive capabilities – from the ninth grade population utilized in this research study (Furlan et al., 2013; Moshman, 2011). This factor does introduce a challenge for comparing the current research study to much of the current body of literature surrounding the implementation of collaborative scripts to promote critical thinking in an academic setting. Even with such a difference, there

were several commonalities to be noted. The current research study discusses Bandura's (1977) social learning theory as a support for how students interact with scripts in a cooperative learning environment. It was mentioned that students would serve as models for one another, thus improving how students appropriate the scripts and allowing the scripts to serve as more meaningful scaffolds to their learning. Similarly, Deiglmayr and Schalk (2015) studied how scripts were modeled by students for their peers and used their findings to establish a rationale for introducing scripts into regular classroom instruction. Lin (2020) noted that students readily interacted with the scripts and seemed to exert effort to be part of the overall team – as was noticed in the current research study. Harney et al. (2017) and Olesova et al. (2016) implemented scripts which focused on higher levels of questioning to promote deeper thinking processes such as the current research study did. Heimbuch et al. (2018) and Schwaighofer et al. (2017) conducted a statistical analysis with a pretest and posttest which surrounded the intervention of collaborative scripts, as the current research study did. Observing commonalities between the current research study and previous studies that have found statistical significance in their collaborative script interventions offers insight for future research recommendations.

This research study intended to implement collaborative scripts in the classroom setting to measure how they may promote the development of critical thinking skills for ninth grade science students. Critical thinking is a significant topic of conversation in the field of education (Abrami et al., 2008; 2015), and there is an abundance of research studies on the matter (Amrullah & Suwarjo, 2018; Co, 2019; Erdogan, 2019; Holmes et al., 2015; Horn & Veermans, 2019; Kusumoto, 2018; Singh & Kumar, 2015, Vieira & Tenreiro-Vieira, 2016). Like the current research study, several researchers have implemented interventions to promote gains in critical thinking skills (Amrullah & Suwarjo, 2018; Erdogan, 2019; Vieira & Tenreiro-Vieira, 2016).

Some of the research studies that found statistical significance on critical thinking gains utilized rather large sample sizes (Loes & Pascarella, 2017; Yin & Fitzgerald, 2017). Many researchers, however, found statistical significance while using smaller sample sizes than that of the current research study (Demirci, 2017; Erdogan, 2019; Hakim et al., 2018; Hidayati, 2017; Kusumoto, 2018; Lee, 2018; Ramirez & Monterola, 2019; Saputra, 2018; Vieira & Tenreiro-Vieira, 2016; Wati & Fatimah, 2016). From the current body of literature, it does not appear that a large sample size is necessary for employing effective interventions that impact the development of critical thinking skills.

The CCT-X was the instrument used to measure critical thinking skills for several research studies in which a significant gain in critical thinking skills was found (Bati & Kaptan, 2015; Bigozzi et al., 2018; Demirci, 2017; Erdogan, 2019; Intarit, 2017; Kwan & Wong, 2015; Muhammad et al., 2015; Vieira & Tenreiro-Vieira, 2016; Yin & Fitzgerald, 2017). Interventions such as cooperative learning with reflective thinking exercises (Erdogan, 2019), profound questioning techniques (Vieira & Tenreiro-Vieira, 2016), discussions involving concept cartoons (Demirci, 2017) and case studies (Intarit, 2017), inquiry-based learning (Kwan & Wong, 2015), and modeling-based learning (Bati & Kaptan, 2015) were implemented to assess subsequent critical thinking skills, as measured by the CCT-X. Like the current research study, each of these studies incorporated methods in which a social aspect was apparent and would be supported by one or more of the theoretical frameworks discussed in this study. Such research results demonstrate increased support for various instructional options for diverse classroom settings with the focus of higher order thinking processes – particularly in a social context. The current research results, while not statistically significant, do support a continued effort to examine

various methods of collaborative instructional pedagogy that may promote the development of critical thinking skills among adolescent students.

### **Implications**

Critical thinking is a widely discussed topic in the field of education (Alsaleh, 2020; Altanis et al., 2018; Johnson & Hamby, 2015; Pérez et al., 2018; Tan, 2017b), and it has many implications in an advancing society of medical, technological, and engineering development (Abadzi, 2016; Cruz et al., 2020; Rampersad, 2020). The ability to engage in critical thinking in the 21st century is crucial, as one must be able to analyze and question presented information, organize solid arguments, and solve a variety of complex problems (Morris, 2017; Pilgrim et al., 2019; Sellars et al., 2018). This research study contributes to the current body of literature regarding how critical thinking skills can be cultivated in the classroom setting. The study was conducted to test the use of collaborative scripts, as well as gain insight regarding collaborative scripts as an instructional method in the acquisition of critical thinking skills among students in the secondary science classroom.

Plenty of research supports the notion of incorporating collaboration into classroom instruction to promote gains in critical thinking skills (Fung et al., 2016; Gillies, 2016a; 2016b; Lin et al., 2015; Singh & Kumar, 2015; Slavin, 1986). This research study also focused on a collaborative component. Several research studies discuss the importance of cooperative peer discourse to ensure all group members are engaged in group discussions (Erdogan, 2019; Johnson & Johnson, 2009; Kyndt et al., 2013; Loes & Pascarella, 2017). This research study aimed to increase cooperation through the use of the scripts. Additionally, numerous research studies support the use of collaborative scripts in a groupwork environment to stimulate peer discussions that are successful and meaningful throughout scaffolded instruction (Lee, 2018; Lin,

2020; Ludvigsen et al., 2016; Näykki et al., 2017; Olesova et al., 2016; Tan, 2018; van der Meij & Leemkuil, 2019; Vogel et al., 2017). This research study also concentrated on meaningful discourse as a scaffolded guide to develop critical thinking skills.

The research is lacking, however, on how collaborative scripts can be utilized as a tool to guide meaningful peer discourse that may result in the cultivation of critical thinking skills in the secondary science classroom setting. This research study is significant because it investigated how the implementation of collaborative scripts in a secondary cooperative learning environment might foster the critical thinking skills of those students. Science is a subject which quite often requires critical thought processes, such as those which pertain to inductive exploration and collection and analysis of data (Dowd et al., 2018). Research that focuses on this setting may add beneficial insight to the existing body of literature. Furthermore, much of the research on this topic has been conducted at the postsecondary level (Deiglmayr & Schalk, 2015; Harney et al., 2017; Heimbuch et al., 2018; Lin, 2020; Mende et al., 2017; Näykki et al., 2017; Saputra et al., 2019; Schwaighofer et al., 2017; Wang et al., 2017), where it is expected for critical thinking skills to have previously been developed in preparation for the workforce (Baird & Parayitam, 2019; Penkauskienė, 2019). This research study aids in filling a gap found within the current body of literature. Though the results of this study were statistically insignificant, the growth between pretest and posttest mean scores was found to be greater for the experimental group than the control group, suggesting that similar research studies conducted in the future may produce statistically significant evidence that collaborative scripts are beneficial in developing critical thinking skills.

### **Limitations**

It is necessary to address the limitations within this research study pertaining to both internal and external validity. Threats to internal validity are those which may have caused the results of the study to be influenced by outside factors (Gall et al., 2007). During the duration of this research study, strict social distancing guidelines were in effect due to the Coronavirus pandemic. Participants may not have interacted with one another, with the use of their collaborative scripts, in the same manner they would normally, which could potentially impact the benefit they may have otherwise received from the intervention. The study took place over a period of three weeks, which may not have allowed enough time to benefit from the intervention of collaborative scripts. Surrounding the three-week period, students took the CCT-X as a pretest and posttest. Since the delivered assessment did not change, it is possible that students remembered certain questions and had time to think about or discuss them, resulting in an improved performance on the posttest. Such an occurrence would alter the collected data.

Another concern pertaining to internal validity is regarding the semester in which the intervention was delivered. The participants are enrolled in a school environment in which cooperative learning is emphasized. Ninth graders were chosen as the target participants for this research study because they will not have been exposed to the school's collaborative learning structures as the other grade levels of students will have been. However, since the research study was conducted in the spring semester of the school year, the participants will have had an entire semester to build collaborative skills which may have led to meaningful discussions that promoted insightful periods of critical thinking. In such an instance, the base level of critical thinking skills among participants may have initially been higher than expected, thus leading to



less growth from pretest to posttest for both groups and indicating an inconsequential level of significance upon data analysis.

Threats to external validity are those which introduce challenges in generalizing the research findings to others (Gall et al., 2007). The participant sample in this research study was chosen via convenience sampling due to limited school openings during the Coronavirus pandemic. The sample size was also quite small ( $N=171$ ), and just barely met the requirements for a medium effect size for an ANCOVA at a statistical power of .7 and alpha level of .05 (Gall et al., 2007). With these sampling conditions, it would not be possible to generalize the findings of this research study, regardless of the analysis results.

### **Recommendations for Future Research**

This research study investigated how the implementation of collaborative scripts in a secondary cooperative learning environment might foster the development of critical thinking skills among those students. It is suggested that this research be replicated, but with some recommended adjustments that may address the limitations that were previously identified. These recommendations are presented as a list below.

1. The research study should be replicated once schools have returned to normal instruction, without restrictions such as strict social distancing requirements. This may allow students to interact with their peers and scripts as would normally transpire. It will also present an opportunity for alternative sampling methods.
2. A larger sample size of participants from a variety of schools should be recruited to allow for greater generalizability of the research findings.

3. A longer period in which participants are engaging with and modeling the use of collaborative scripts may result in greater benefit regarding the development of critical thinking skills, so a longer duration of the study should be considered.
4. A different testing instrument may need to be considered to address the concern that students may be remembering test questions from the pretest when taking the posttest. This is particularly necessary to consider if the length of the research study is not being adjusted.
5. The research study should take place at the beginning of the school year to address any concerns of participants having been previously exposed to learning conditions that may alter the impact of the collaborative script intervention.

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## APPENDIX A: Permission to Use the CCT-X

12/25/2020

Mail - Wetherby, Jaime - Outlook

[External] RE: Cornell Critical Thinking Test: Permission to Use

Mon 12/14/2020 5:06 PM

To: Wetherby, Jaime <jwetherby@liberty.edu>

[ EXTERNAL EMAIL: Do not click any links or open attachments unless you know the sender and trust the content. ]

Dear Jaime,

Thank you for your inquiry.

The Cornell Critical Thinking Tests can be administered via paper and pencil or via licensing the rights to use the test within your own software administration program. You can buy the paper and pencil version online in sets of 10 booklets (for USD \$29.99) here:

<https://www.criticalthinking.com/cornell-critical-thinking-tests.html>

You do not need our permission if you plan to use the paper and pencil versions, but please note that you are not allowed to include the test in its entirety or the answers in your dissertation as that would invalidate the test. The sample questions that we posted online are allowed to be included though.

The best way to evaluate the test would be to purchase the Specimen Set, which includes one Level X test booklet and one Level Z test booklet as well as the Manual. The Manual contains administration and scoring information (answers), norms, consistency, reliability, item analysis, and validity for Level X and Level Z tests. Since the test booklets are non-reproducible we do not sell them as eBooks. If you'd like to see some sample test questions and pages from the Manual I'd be happy to send you a PDF.

We license the test for administration via platforms such as Qualtrics, Blackboard, Canvas, Survey Monkey, etc. The cost to administer one test via your platform of choice is \$3.99 (\$2.99 for researchers). We offer volume discounts once the quantity is above 200 tests.

Once we receive a signed license agreement and payment, we will send you the test in various formats (pdf, csv, html, xml) along with the Manual (PDF). You will be responsible for loading the test into the software platform and scoring. We do not have experience with that step but thousands of licensees have done it successfully using Blackboard, Qualtrics, Canvas, Moodle, Survey Monkey, etc..

We will need answers to the following questions if you would like to license the tests:

- 1) Which test level (X or Z, or both) would you like to license? Level X
- 2) How many tests would you like to administer?
- 3) What software administration program will you be using?
- 4) What is your physical mailing address and phone number (that we should use in the license agreement)?
- 5) What is the school name, physical mailing address and phone number?

12/25/2020

Mail - Wetherby, Jaime - Outlook

6) Will a school administrator be signing the contract or will you?

If the school will be signing the contract then we will need the signatory's information as well.

We will draft a licensing agreement and send it upon your reply. Typically the non-exclusive contract is valid for 3 years but we can increase that number if you prefer.

If you prefer to administer the paper and pencil version then please note that we do not sell the answer sheets, but any Scantron answer sheet will work. Depending on your concurrent testing needs, buying the test booklets may be the less expensive option as you can reuse the booklets.

Thank you and best regards,

██████████ Vice President  
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**From:** Wetherby, Jaime [mailto:jwetherby@liberty.edu]  
**Sent:** Monday, December 14, 2020 10:52 AM  
**To:** info@criticalthinking.com  
**Subject:** Cornell Critical Thinking Test: Permission to Use

Good afternoon,

I am currently a doctoral candidate at Liberty University, and I will be conducting my dissertation research on the use of collaborative scripts and the development of critical thinking skills. I would very much like to utilize the Cornell Critical Thinking Test - Level X as the instrument to measure critical thinking skills.

I wanted to inquire how I might obtain permission to do so. Since copies of the test are available for purchase, is it necessary to acquire permission to use the test for my dissertation research? If so, could you please direct me to whom I would speak with regarding this? Thank you so much.

Kind regards,

Jaime Wetherby

**APPENDIX B: IRB Exemption****LIBERTY UNIVERSITY**  
INSTITUTIONAL REVIEW BOARD

January 28, 2021

Jaime Wetherby  
Katie Thompson

Re: IRB Exemption - IRB-FY20-21-504 Incorporating Scripts with Cooperative Learning to Promote Critical Thinking Skills in Secondary Science

Dear Jaime Wetherby, Katie Thompson:

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and no further IRB oversight is required.

Your study falls under the following exemption category, which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:101(b):


Category 1. Research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students' opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies, and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Your stamped consent form can be found under the Attachments tab within the Submission Details section of your study on Cayuse IRB. This form should be copied and used to gain the consent of your research participants. If you plan to provide your consent information electronically, the contents of the attached consent document should be made available without alteration.

Please note that this exemption only applies to your current research application, and any modifications to your protocol must be reported to the Liberty University IRB for verification of continued exemption status. You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this exemption or need assistance in determining whether possible modifications to your protocol would change your exemption status, please email us at [irb@liberty.edu](mailto:irb@liberty.edu).

Sincerely,

  
*Administrative Chair of Institutional Research*  
**Research Ethics Office**

## APPENDIX C: Researcher's Script – Introducing Participants to Study

Hi everyone! Thank you for allowing me to come speak to you today. My name is Jaime Wetherby, and I will be conducting a research study that I would like to explain to you. This study is completely voluntary, which means you are not required to participate, but this study is meant to help educators learn more about what is helpful for students in the classroom. Let me explain what I mean by that.

Sometimes in school we learn information that we must recall later – especially if we end up having a test on that information. However, it is also very important to learn how to think through problems. Sometimes, if you do not know the immediate answer, you can use your thinking skills to arrive at the answer anyway. For example, a few years ago I heard a doctor use the term “cardiomyopathy.” I had no idea what that word meant at first. I started doing a bit of a mental investigation by taking what I knew about word roots. I knew that “cardio” refers to the heart, “myo” refers to muscle, and “pathy” refers to a disease or disorder. I deduced that this word meant something was wrong with the heart muscle. Later, I learned that cardiomyopathy is just a fancy medical term for a weakened heart.

The reason I tell you that story is because it relates to the use of critical thinking skills. Even without having heard, much less memorized, the term “cardiomyopathy” before, I was able to determine – at least somewhat – what the doctor was communicating. In today’s society, it is more important than ever to be able to think critically through problems. Advancements in the medical, technological, engineering, and other career fields rely on people who can analyze, reason through, and formulate new conclusions and ideas. This research study is going to investigate how a particular type of instruction may promote the development of critical thinking skills for ninth grade science students.

As I explain to you what this study entails, please think about any questions you would like to ask me at the end. Feel free to write your questions down in case you forget what you wanted to ask.

If you agree to participate in this study, I will ask you to begin by taking a test called the Cornell Critical Thinking Test, Level X. It has 76 questions and it takes about 50 minutes to complete. Don’t worry – it does not impact your grade in any way. The reason I ask you to take this test at the beginning is because you will take it again at the end; that way, I can look at your scores before and after we try this new instructional method. The next step will involve a pilot study, which is basically just practice to ensure we all know what to do. You will receive paper handouts called collaborative scripts, and these scripts will contain questions that you may ask your group members while you are working on your lesson. They provide you with guidance to allow for meaningful group discussions; they also prompt you to think a little deeper than you may have done otherwise. The scripts will have you asking each other questions such as “why” and “how”?

Once everyone is comfortable with how to use the scripts, we will continue class instruction for the next three weeks in a normal manner. The only difference is that you may also have the scripts to help you engage in your group discussions. Your class may not get the scripts. Your class may continue like nothing is different. It will be randomly decided which classes receive the scripts and which ones do not. We need to make sure that some students use the scripts and some do not so that we can effectively compare the two groups at the end. Please know that you may or may not be in a class that uses the scripts. You will still be considered part of the study, however. If you do just as well on your post-test as the students in the other classes, then we cannot attribute the success to the use of the scripts. Therefore, we need to have half of the students use the scripts and half of the students not use the scripts.

After the three weeks have ended, I will ask you to take the Cornell Critical Thinking Test, Level X again. This test also does not impact your grade in any way. I want to make it very clear that your participation in this study is completely voluntary. You can choose not to participate – or you can change your mind later and decide to withdraw. There will be no penalty, and nobody will be upset with you. However, I also want to be very clear about what that means. If you choose not to be part of the study, it does not mean that you will not participate in class in whichever manner the teacher instructs – even if that class period involves the use of the collaborative scripts. It is still a lesson that your teacher is delivering to you, just like any other day. What it means to not participate in the study is that you will not be required to take the Cornell Critical Thinking Test, and, if you do, I will not collect and analyze your test scores. If you are not taking the test during the time the rest of the class is taking it, you will be working on a different activity that your teacher chooses that is related to topics you were introduced to in the course previously. Speaking of the Cornell Critical Thinking Test, I will never know which test scores belong to which students. You will create your own code name, which will be your favorite color, favorite animal, and last four digits of your phone number. It is silly, but it will be easy for you to remember. For example, I might be looking at the test scores for a student named BlueShark5678. I will have no idea who BlueShark5678 is.

So far, what are some things I can clarify for you? Are there any questions you think your classmates may currently have? [Allow think time for questions.]

I will now hand out an assent form, which is a permission form for you to sign if you agree to take part in this study. Please take a moment to read over it. Ask any questions you have and point out anything you may be unsure about. You do not need to sign this form today, but if you choose to, I can collect it from you today. I will ask you to return this form within five days. If I am not here, you may hand it to your teacher, who will ensure that it comes to me. I will also give your teacher many extra copies in case yours gets lost for any reason. If you choose to not participate – or if you do not return the form – I will meet with you to discuss any concerns you may have regarding this study or anything that may prevent you from wanting to participate. [Allow time to read over the assent form, as well as think time for questions.]

Now that you have had time to read over the assent form, what are some things I can clarify for you? Are there any questions you think your classmates may currently have? [Allow think time for questions.]

I have sent a form home to your parents as well. There is an extra form which includes my contact information. You may call or email me with any questions you have, and I will be more than happy to answer those questions. If any of you are willing to turn your form in today, I can collect it from you now. Please remember that you can still change your mind if you decide later on that you do not want me to include your scores in my data analysis. [Allow time for students to complete and turn in any assent forms that are being signed and returned today.]

## APPENDIX D: Collaborative Scripts

### Week One/Script One

Focus question: Why must the Earth have developed in the specific layers that it did?

#### **Direct Questions:**

- Why do you think Earth is considered to be in layers?
- In which ways are Earth's layers similar to one another?
- In which ways are Earth's layers different from one another?
- How is the transfer (or movement) of energy measured?
- How do you think energy transferring through Earth's layers may be examined to determine the densities of each of Earth's layers?
- How do you think the knowledge of each of the layers' densities may lead one to learn the chemical composition of Earth's layers?
- How do you think the knowledge of each of the layers' densities may lead one to guess the temperature and state of matter for each of the layers?
- If a baker were to bake a layer cake that simulated the layers of Earth, which types of ingredients would it make sense to use for each layer?
- Why might it be important to know the various physical properties of the different layers of the Earth?
- Why might it be important to study how energy moves through each of the layers of Earth?
- From what we know about the properties of each layer, do you think it possible for Earth's composition to change over time?
- How may the force of gravity have played a role in Earth's construction?

#### **General/Follow-Up Questions:**

- So far, what does everyone understand?
- What do you think we should look into next?
- Can anyone explain (this part) to me?
- Can you give an example of what you mean?
- Can you explain why you think that?
- Do you think there could be any other explanation?
- How can we try to find out the answer to this question?
- Can we find some evidence to support this claim?
- How do we know this is true?
- What can we conclude based on what we have said?
- How can we summarize or paraphrase (this concept)?
- What do you think may have caused this/that?
- What do you think may be impacted as a result?
- What thoughts led you to think that?
- Is there a different way we can look at this?
- Is there anything this reminds us of?
- What can help us remember this? Is there anything we can relate it to?
- What did we learn previously that may help us with figuring this out?

### Week Two/Script Two

Focus question: How might we expect the surface of Earth to look over time as the crust shifts in different ways?

#### Direct Questions:

- Why might Earth's crust be split into various pieces called "plates"?
- Why do you think the continents may not always be the entire size of the plate?
- How must *each* of the plates have moved over time to shift to where they are now vs. where they were with Pangea?
- When thinking about energy transfer and transformation, as learned in a previous unit, why do you think people can feel Earthquakes from many miles away?
- How might a scientist determine where an Earthquake originated?
- How might the plates move on Earth in relation to one another?
- What evidence exists to support the theory of continental drift?
- How might plate movement affect the structures of the land?
- What might transpire due to the shifting of plates under water?
- How can Earthquakes be explained?
- How might volcanic and mountainous structures be formed when plates move?
- How might plate movement result in volcanic eruptions?
- How might valleys form when plates move?
- What might scientists learn about new and old crust by investigating seafloor spreading?

#### General/Follow-Up Questions:

- So far, what does everyone understand?
- What do you think we should look into next?
- Can anyone explain (this part) to me?
- Can you give an example of what you mean?
- Can you explain why you think that?
- Do you think there could be any other explanation?
- How can we try to find out the answer to this question?
- Can we find some evidence to support this claim?
- How do we know this is true?
- What can we conclude based on what we have said?
- How can we summarize or paraphrase (this concept)?
- What do you think may have caused this/that?
- What do you think may be impacted as a result?
- What thoughts led you to think that?
- Is there a different way we can look at this?
- Is there anything this reminds us of?
- What can help us remember this? Is there anything we can relate it to?
- What did we learn previously that may help us with figuring this out?

### **Week Three/Script Three**

Focus question: How do Earth's layers impact one another to ultimately result in plate movement?

#### **Direct Questions:**

- How does heat impact the movement of particles within a substance?
- Why would heating the bottom of a pot of water cause the water to come to a boil?
- Why might scientists have divided the mantle into two sub-sections?
- Why might density be different between the upper and lower mantle?
- How do temporal differences between the upper and lower mantle result in currents?
- Why do you think the magma within the upper and lower mantle never reaches equilibrium?
- How can the densities of Earth's layers be connected to the movement within the mantle?
- How can movement of the mantle impact the crust above it?
- What might happen when crust is subducted into the mantle?
- How might one relate the rising of magma at a subduction zone to climbing into a bathtub filled to the top with water?
- Why would different formations occur in different crust locations where the mantle's currents are different below?
- In what various ways might the convection currents in the mantle change that would cause the crust to be impacted differently?
- How does energy transfer and transform throughout the various layers of Earth?
- How can Earth's changing dynamics be related to its original formation?

#### **General/Follow-Up Questions:**

- So far, what does everyone understand?
- What do you think we should look into next?
- Can anyone explain (this part) to me?
- Can you give an example of what you mean?
- Can you explain why you think that?
- Do you think there could be any other explanation?
- How can we try to find out the answer to this question?
- Can we find some evidence to support this claim?
- How do we know this is true?
- What can we conclude based on what we have said?
- How can we summarize or paraphrase (this concept)?
- What do you think may have caused this/that?
- What do you think may be impacted as a result?
- What thoughts led you to think that?
- Is there a different way we can look at this?
- Is there anything this reminds us of?
- What can help us remember this? Is there anything we can relate it to?
- What did we learn previously that may help us with figuring this out?



## **APPENDIX E: Researcher's Script**

### Explanation of Collaborative Scripts to Students

#### Part one: Pilot study

Thank you all so much for agreeing to take part in this research study. You may remember from previous discussions that we will be using something called “collaborative scripts” while working through this next unit in science class. It is very important that we use these scripts the way they were intended to be used; therefore, we will practice using them today. I will come around to you, individually, with a box of scripts, and I ask that you only take the script at the top of the pile. Please note that these scripts are laminated so they may be sanitized with cleaning wipes in between use for each class.

While looking at your script, you may notice that it contains many different questions. Each of you is currently holding a copy of the same script. When you are in small groups with your classmates – and working on your lesson – you will be able to reference your script to ask your group members questions that will guide your discussions and learning. It is necessary that each of you ask your group members a minimum of three questions from the script per class period while working on this unit. Doing so will be considered a good use of the scripts. Let me give you an example of how to use your script. I may ask my group members to consider one of the direct questions on the list, such as: “When thinking about energy transfer and transformation, as learned in a previous unit, why do you think people can feel Earthquakes from many miles away?” As the group discussion ensues and members provide their thoughts on the topic, I may choose to follow up with one of the general questions on the script, such as: “Why do you say that?” or “Can you provide an example?”

So far, what are some things I can clarify for you? Are there any questions you think your classmates may currently have? [Allow think time for questions.]

Please note that if you have any questions about how to use the scripts during our practice session, you are quite welcome to ask. I would be more than happy to answer your questions. The last thing I would like to mention is that, while you move through this unit's lesson, you will all receive a new script that includes questions which align more specifically with what you are learning. Each student in the class will always have the same script as everyone else, but we will all use new scripts when we move to a new part of the lesson each week. We will only use this script for practice today. Please remember that your goal is to ask at least three questions from this script today. This will be good practice for asking a minimum of three questions every class period when we use these scripts going forward.

In a moment, I am going to ask that the tallest member of the group begin the group discussion by choosing one of the direct questions on the script to ask the group. Are there any questions before we begin? [Allow think time for questions.] Let's get started with the tallest member of each group; please begin now.

### Part two: Beginning of study

It is so great to see all of you again. Thank you so much for practicing the use of the collaborative scripts the last time we saw each other. Just to remind you – you needed to ask your group members a minimum of three questions from your script. I would like to add that any of the questions from your scripts may be asked more than once – particularly if they are general questions, or if they are questions you would like to revisit as a group. Were there any questions

that any of you thought of regarding the use of these scripts since we last spoke? Are there any questions you think your classmates may currently have? [Allow think time for questions.]

We are now going to use the collaborative scripts as a part of your science lesson. Your teacher explained to me that this lesson should take about four weeks to complete, and you will meet twice a week for this class. You will be provided a script to use during each of the first three weeks, as I understand the fourth week will be dedicated to creating and giving your final presentation. Each day we meet as a class, it is necessary that you use the collaborative scripts to ask at least three questions of your group members. You are more than welcome to ask more than three questions, but three is the minimum number of questions for you to ask to make good use of your scripts. Your teacher will begin the lesson as it would normally transpire. The only part that is different is having the collaborative scripts available to you to use during your group discussions, whereas you would typically have no such scripts. Now I would like to offer the opportunity to ask questions again before your teacher begins the lesson. [Allow think time for questions.] Again, I thank you very much for your participation.

**APPENDIX F: Teacher’s Lesson Plan****Lesson Plan: Dynamic Earth****General Information**

**Subject:** Integrated science

**Grade Level:** 9th

**Topic of Study:** Properties of the layers of Earth, constructive and destructive forces on/within Earth, causes and effects of convection currents in the mantle, tectonic plate movement, energy transfer and transformation through Earth in relation to various formations and events, and cycling of matter within the various layers of the Earth

**Driving Question:** How might the surface of the Earth look in 100 million years, and why?

**Setting for Instruction:** Instruction will take place in a collaborative classroom setting with a facilitating teacher and paraprofessional. Desks will be positioned to face one another to support groups of three or four students. Desk positions will allow three feet of space for social distancing efforts, and all students will be mandated to wear masks to align with state-identified public health guidelines.

**Standards/Objectives**

**Achievement Standards and Objectives:** This lesson will adhere to the National Next Generation Science Standards (NGSS). These standards also identify the desired lesson objectives by stating which actions students will be able to successfully complete.

- HS-ESS2-1 Earth's Systems: Develop a model to illustrate how Earth’s internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.
- HS-ESS2-2 Earth's Systems: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
- HS-ESS2-3 Earth's Systems: Develop a model based on evidence of Earth’s interior to describe the cycling of matter by thermal convection.
- HS-PS2-1 Motion and Stability: Forces and Interactions: Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- HS-PS3-2 Energy: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
- HS-PS4-4 Waves and their Applications in Technologies for Information Transfer: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

- HS-PS4-5 Waves and their Applications in Technologies for Information Transfer: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

### Resources for Instruction

**Instructional Materials:** Disposable clay for modeling Earth’s layers and effects of constructive and destructive forces, cut-and-paste puzzles to connect evidence for continental drift, convection currents lab kits, 1:1 Chromebooks for visiting supplied resources

**Resources:** Various media, including articles, videos, interactive simulations, and hands-on materials (see “presentation of material”); peer discourse in small groups, with teacher facilitation

### Instructional Framework

**Connections to Prior Learning/Skills:** Prior to this unit, students will have learned introductory physics concepts, such as those pertaining to kinetic and potential energy, transfer and transformation of energy, properties of waves, forces, kinematics, and Newton’s laws of motion. This learning will relate to the various constructive and destructive processes on Earth, which occur due to the moving tectonic plates that comprise the crust and the movement within the mantle layer of the Earth. Students will have also learned introductory chemistry concepts, such as those pertaining to conservation (or recycling) of matter and the changes of matter which result from temperature fluctuations. These concepts will relate to the movement within the mantle layer of the Earth (which initiate movement of the crust), as well as how Earth’s layers recycle into one another as constructive and destructive forces naturally take place.

**Presentation of Material:** The material will be presented in three parts – one part per week.

- Week One: The Earth in Layers
  - Presentation of video phenomenon – Earth’s constructive and destructive processes
  - Presentation of overall driving question: How might the surface of the Earth look in 100 million years, and why?
  - Presentation of question to focus on for this week: Why must the Earth have developed in the specific layers that it did?
  - Earth layers informational article
  - Earth layers online interactive simulation
  - Chemical composition of Earth layers interactive puzzle simulation
  - Modeling Earth’s layers with disposable clay
  - Benchmark assignment: small group discussion with individual written responses to answer weekly question: Why must the Earth have developed in the specific layers that it did?
- Week Two: Continental Drift/Tectonic Plates/Constructive and Destructive Forces

- Presentation of question to focus on for this week: How might we expect the surface of Earth to look over time as the crust shifts in different ways?
- Phenomenon of continental drift video
- Continental drift with evidence cut-and-paste puzzle
- Evidence for continental drift article
- Constructive and destructive forces online interactive simulation
- Presentation on boundaries and fault lines
- Presentation regarding plate movement and the resulting formations/events on the crust
  - Clay modeling of constructive and destructive forces
- Benchmark assignment: small group discussion with individual written responses to answer weekly question: How might we expect the surface of Earth to look over time as the crust shifts in different ways?
- Week Three: Convection Currents as the Driving Force
  - Presentation of question to focus on for this week: How do Earth's layers impact one another to ultimately result in plate movement?
  - Convection currents lab activity
  - Convection currents in Earth video
  - Flowchart: mantle moving the crust
  - Benchmark assignment: small group discussion with individual written responses to answer weekly question: How do Earth's layers impact one another to ultimately result in plate movement?
- Week Four: Create Group Presentation
  - Prompt to research the speed and direction of all plates' movements
  - Answer driving question: How might the surface of the Earth look in 100 million years, and why?

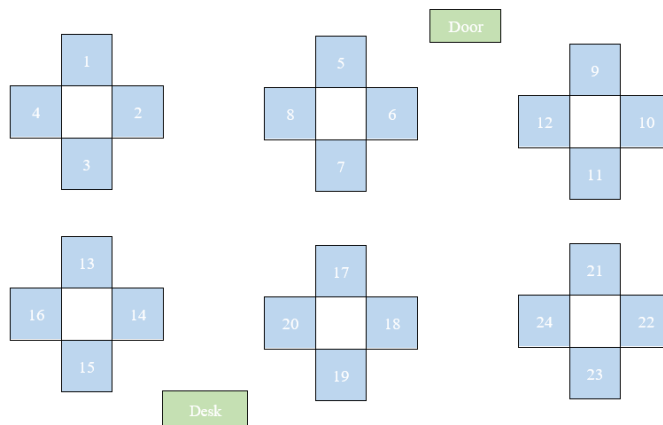
**Instructional Strategies:** This unit will follow the project-based learning (PBL) format of all prior units. Students will initially be presented with a phenomenon of Earth's constructive and destructive forces, as well as the driving question: How might the surface of the Earth look in 100 million years, and why? Students will then be provided with various scaffolded activities in different formats (video, article, interactive simulation, hands-on materials, etc.), to work through and discuss with group members to ultimately answer the driving question.

**Assessment(s) of Learning:** Formative assessments will involve listening to group discussions, as well as assigning a brief, written benchmark assignment at the end of each week. The summative assessment will involve a group presentation of how the group members believe the surface of the Earth will look in 100 million years, as well as their explanation as to why.

### APPENDIX G: Checklist for Tracking Student Use of Scripts

**Checklist: Track Student Use of Scripts**

**Class Period:** \_\_\_\_ **Date:** \_\_\_\_\_



<u>Student</u>	<u>Use of Scripts (Checkmark)</u>			<u>Student</u>	<u>Use of Scripts (Checkmark)</u>		
Seat #: 1				Seat #: 13			
Seat #: 2				Seat #: 14			
Seat #: 3				Seat #: 15			
Seat #: 4				Seat #: 16			
Seat #: 5				Seat #: 17			
Seat #: 6				Seat #: 18			
Seat #: 7				Seat #: 19			
Seat #: 8				Seat #: 20			
Seat #: 9				Seat #: 21			
Seat #: 10				Seat #: 22			
Seat #: 11				Seat #: 23			
Seat #: 12				Seat #: 24			