LEVERAGING SIGNALING TO PREVENT COGNITIVE DISENGAGEMENT IN VIRTUAL MIDDLE SCHOOL STUDENTS: A TRANSCENDENTAL PHENOMENOLOGICAL STUDY

by

Mandira Maria Gerrels

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

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Abstract

The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. The theories guiding this study were Sweller's cognitive load theory and Mayer's cognitive theory of multimedia learning as they explain the relationship between learning capacity and optimizing the online learning process through signaling. These theories set the foundation for the following central research question: what are the lived experiences of virtual middle school students during cognitive disengagement and signaling? After thoroughly investigating previous research within the literature review, this transcendental phenomenological study followed Moustakas' framework. After receiving IRB approval from Liberty University, the parent company (Orion) and Rigel virtual school, a sample of middle school students were polled from a well-established upper Midwest American virtual school. Data was collected using a triangulation of three distinct methods: individual interviews, questionnaires, and focus groups. The targeted participatory group of 15 scholars provided diverse backgrounds and perspectives. The data was analyzed using Saldaña's coding method. Trustworthiness and ethical implementation have been extensively considered. The culmination of the shared lived experiences of the 15 participants resulted in three themes: student empowerment through virtual learning, cognitive threshold processing, and virtual learning strategies. Additionally, there were six corresponding subthemes: freedom to learn, student driven, metacognition, the rogue brain, augmenting modalities with multimedia approaches, and effective signaling for virtual learning.

Keywords: cognitive architecture, cognitive disengagement, extraneous cognitive load, germane cognitive load, intrinsic cognitive load, signaling, virtual learning

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Dedication

I dedicate this dissertation to the good Lord for leading me through this exciting and challenging journey. His Holy Spirit has provided me guidance and clarity of thought. The good Lord also blessed me with many crucially important people to support me along the way. To Him be all the glory.

I dedicate this dissertation to my wonderful husband Caleb and our furry companion (and my office buddy) Radar Gerrels. Thank you for your continual love and support throughout the entire process. Caleb, I could not have asked for a better partner and best friend to hold down the fort and take care of so many delicious meals. Thank you for believing in me and supporting me through the long hours (and mess of notebooks). I could not have made it through this season without the support of trio awesome!

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List of Abbreviations

Cognitive Load Theory (CLT)

Cognitive Theory of Multimedia Learning (CTML)

Extraneous Cognitive Load (ECL)

Germane Cognitive Load (GCL)

Intrinsic Cognitive Load (ICL)

Institutional Review Board (IRB)

Learning from Home (LFH)

Online and Distance Education (ODE)

Self-Regulated Learning (SRL)

CHAPTER ONE: INTRODUCTION

Overview

Virtual education is on the rise, yet understudied (Beeman, 2022). The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. In order to fully comprehend this subject, the topic's background is fully investigated in this chapter. The evolution of virtual learning is discussed along with an analysis of the social systems influenced by the issue of cognitive disengagement. Essential theoretical concepts are examined as well as the principles that form the foundation of this research. After addressing the problem and purpose of the study, the significance of the study is expressed. This chapter concludes with the research questions and summary.

Background

Twenty-first century learners and families have a variety of educational delivery options. While virtual learning and hybrid models were previously common for collegiate levels, brick-and-mortar dominated the primary and secondary education levels until the COVID-19 global pandemic (Adedoyin & Soykan, 2023; Carter et al., 2020). Online students have significantly lower academic performance and are consequently less likely to graduate in comparison to their in-person counterparts (Xiao et al., 2020; Zhang & Lin, 2020). Virtual school performance can be particularly disturbing because they are held to the same standards as in-person institutions (Beldarrain, 2006). Learning disengagement leads to absenteeism, drop out, and continues to be an increasing issue (Daily et al., 2020; Huh et al., 2019). Nationally, only 9% of educators reported student engagement during COVID-19 distance learning (Domina et al., 2021). Virtual learning must operate differently (Beldarrain, 2006). Reasons for dropping out can be grouped

into four main categories: internal, external, personal characteristics, and skills (Bağriacik & Karataş, 2022). A domineering topic in retention research is student engagement (Beck et al., 2022; Bergdahl et al., 2020). Virtual school students undergo the highest form of cognitive engagement because learning is independent and requires active thinking (Agustini et al., 2022). While much is already known about how students cognitively engage, this study is necessary to fill in the gap of combatting the causes of cognitive disengagement.

Historical Context

Unlike the expansive history of education, organized virtual or online learning began in the 1990s during the digital era (Toppin & Toppin, 2016). E-learning's accretion started as a supplement to offer accelerated programs (Oliver et al., 2009). Initially, elite learners had a penchant for virtual education due to its flexibility, reduction of distractions, and high rigor (Agustini et al., 2022; Eden et al., 2022; Xiao et al., 2020). The desire to improve instructional design led many universities to begin transitioning courses to hybrid and full e-learning models (Kew & Tasir, 2021). On the other hand, primary and secondary level school districts integrated educational technology within the brick-and-mortar classroom first (Magana et al., 2022). In the early 2000s, districts began opening online education programs to all students (Barbour, 2022).

As technology continued to flourish, so did education's simultaneous metamorphosis. Among the different varieties of online learning, virtual charter schools have risen as the domineering form of K-12 online delivery and operate in at least 28 states (Ford, 2022). According to Beck and Beasley (2021), 44 out of 50 states now have virtual schools. Moreover, adding credit recovery to virtual programs led to a shift in student clientele (Oliver et al., 2009). Soon after, virtual learning became an attractive alternative for students with learning exceptionalities due to the individualized learning and respite from social pressures such as

bullying (Repetto et al., 2010).

Online education has also been highly attractive in the professional realm. Simulations and virtual reality are effective alternatives- especially for training that would otherwise be dangerous, expensive, or real world impossible (Andersen & Makransky, 2020). Simulations and gamification of educational technology have also shown to enhance learning (Magana et al., 2022). For example, clinical simulations were found to be an ideal method to promote deep reflective thinking and provide professional experience without inexperienced threat to patient well-being (Verkuyl et al., 2018). Simulation integration is an evolutionary next step of virtual education that has already been implemented by corporate America (Bean, 2014; Hummel et al., 2017; Liberman & Dubovi, 2023).

While this advanced level of virtual education is primarily integrated at the post-secondary level, K-12 education has begun to use multimedia to enhance student achievement (Mash et al., 2020; Tapingkae et al., 2020). Multimedia learning has many roots and began emerging as a research focus to combat split attention (Sentz et al., 2019; Tarmizi & Sweller, 1988). According to Clark and Mayer (2016), the multimedia principle explains that people learn better through the use of visuals and text over text alone. Signaling is among these forms of multimedia that reduces split attention by directing learner focus to critical information (Ginns et al., 2020; Moon et al., 2022; Pi et al., 2021). An archaic version of signaling was the bouncing ball in early animations (Arslan-Ari & Ari, 2021). Closed captioning is an evolved form that enhances accessibility for all students (Asim et al., 2020; Stull et al., 2021).

Another significant event to alter the development of virtual education was the global COVID-19 pandemic as brick-and-mortar teachers and students were thrust into online, distance learning (Carter et al., 2020; Eden et al., 2022; Seymour et al., 2020; Stull et al., 2021; Zhong &

Lyu, 2022). Virtual schools had the advantage during this time as online educators were equipped with the skills to differentiate instruction and meet the learning needs of digital learners (Asim et al., 2020; Domina et al., 2021). Although, the pandemic experience did give virtual school educators insight into the significant role of technology and requirement of digital literacy development (Xiao et al., 2020). Digital literacy is the competence and fluency of multimodal technology navigation and processing (Ng, 2012; Reedy & Parker, 2018). Students with low digital literacy are more likely to drop out (Bergdahl et al., 2020). Therefore, educators need to ensure curriculum is appropriate and does not lead to cognitive disengagement (Eden et al., 2022; Liu et al., 2022; Sentz et al., 2019; Webb et al., 2022).

Social Context

The pandemic caused educational setbacks that impacted families and left students to feel displaced and disengaged (Devkota, 2021). Internationally, students were forced to embrace learning from home and found themselves at the mercy of technology's reliability (Pratama & Firmansyah, 2021). Inequities in socioeconomic home situations impacted engagement levels during distance learning (Devkota, 2021). According to Domina et al. (2021), 15% of students in a Los Angeles school district reported never logging in. Even for the highly motivated students, virtual educators need to consider the learning design for all students due to the individuality of the online paradigm (Carter et al., 2020).

In comparison to their other grade level counterparts, middle school students are at higher risk for disengagement in learning (Asim et al., 2020). The biological changes that occur during adolescence can contribute to rapid cognitive development as well as increase sensitivity to stress and resistance to change (Asim et al., 2020; Jopling et al., 2021). However, middle school

students tend to have a slightly more positive perception of school-climate (due to positive teacher connections) compared to high school students (Daily et al., 2020).

There are many reasons why the middle year ages were selected for this investigation. Middle school students are rarely the focal age group studied (Beege et al., 2021; Semeraro et al., 2020). Additionally, secondary students are a great risk of academic failure because of losing focus or falling behind; furthermore, virtual schools serve a much higher percentage of these at-risk students (Asim et al., 2020). The iGen learners of today hold expectations for educational technology to be fluent and prepare them for real world digital activities (Power & Kannara, 2016). Hence, middle school students are ideal candidates for this study as they have a predisposition to gamification and multimedia learning (Abraham et al., 2022).

Theoretical Context

Cognitive load theory (Sweller, 1988, 2011) and the cognitive theory of multimedia learning (Clark & Mayer, 2016; Mayer, 1999, 2014, 2017; Mayer et al., 1996) are logical foundational theories in order to explore how signaling can be used to prevent cognitive disengagement in virtual middle school students. Cognitive load theory (CLT) capitulates that learning happens as a result of optimizing cognitive architecture which is composed of extraneous, germane, and intrinsic cognitive loads (Sweller, 2020). Working memory is where active learning occurs and is comprised of these three loads (Huh et al., 2019; Krieglstein et al., 2022a). The cognitive theory of multimedia learning (CTML) explains that learning is fostered when words (auditory and visual) are combined with static or animated pictures (Mayer, 2017). Virtual education adds a cognitive dynamic due to the inclusion of technology and need for digital literacy; therefore, CTML is essential as a secondary theoretical framework (Guo et al., 2020; Li et al., 2020a, 2020b).

Both CLT and CTML theoretical frameworks are grounded in three assumptions that impact how instructional design should support learning: dual processing channels, limited capacity, and active engagement (Alpizar et al., 2020; Arslan-Ari & Ari, 2021). Dual processing comes from Clark and Paivio's (1991) dual coding theory. Learning begins with environmental stimuli that is taken in through various sensory channels (Dirksen, 2016). Efficient learning happens when new information is spread across auditory and visual channels rather than overloading one (Clark & Mayer, 2016; Clark & Paivio, 1991). Next, the stimuli are processed as new information in working memory (Dirksen, 2016). According to CLT, working memory is a balance of cognitive architecture (Sweller et al., 1998). Extraneous and intrinsic cognitive loads are derivatives of the informational channels (Bahari, 2022). Germane cognitive load is the bridge between working memory and long-term memory- the ultimate destination of the learning paradigm (Altmeyer et al., 2020; Andersen & Makransky, 2020). Essentially, the visual and verbal integration from dual channeling leads to new schema acquisition which allows learns to combine new information with prior knowledge (Bahari, 2022; Mutlu-Bayraktar et al., 2019).

The second assumption (limited capacity) is grounded in Baddeley's (1986) theory of working memory. Also known as short-term memory, working memory has a limited capacity (Baddeley, 1986, 2010; Krieglstein et al., 2022a; Sweller et al., 1998). Cognitive overload is most directly associated with superseding working memory's limited capacity which is influenced by complexity of task, prior knowledge, and the learners' self-belief (Jopling et al., 2021; Makransky & Mayer, 2022; Xu et al., 2021). In contrast, long-term memory is unlimited; hence, schema building in long-term memory being a terminal goal of learning (Andersen & Makransky, 2020; Baddeley, 1986, 2010; Bahari, 2022; Magana et al., 2022). Similarly, cognitive level can increase if the task level is too difficult; thus, negative thinking may be

created as a consequence which will further deplete cognitive capacity (Baten et al., 2020; Vygotsky, 1987).

Active engagement is the third and pinnacle assumption of CLT and CTML (Mayer, 1999; Sweller et al., 1998). Student-centered learning is rooted in Piaget's (1964) constructivism. When technology is combined with pedagogy and multimedia content, 21st century learning best practice emerges (Almasseri & AlHojailan, 2019; Altmeyer et al., 2020; Asim et al., 2020; Guo et al., 2020; Ring et al., 2021). Moreover, this third assumption derives from engagement theory and self-determination theory. Kearsley and Shneiderman's (1998) engagement theory states that students have richer learning experiences when actively focused on meaningful activities perpetuated by technology integration. Affective, behavioral, and cognitive engagement can be positively influenced by technology when facilitated appropriately (Beldarrain, 2006; Eden et al., 2022; Jian et al., 2022). In alignment with Deci and Ryan's (1980, 1985, 2020) self-determination theory, CLT and CTML assume that the learner is intrinsically motivated with a desire to learn. Intrinsically motivated learners were particularly important to distinguish for the investigation into cognitive disengagement as there was already ample research on extrinsic motivation and behavioral disengagement—both of which were not a focus for this study. Students with high cognitive engagement are correlated with being self-determined (Baten et al., 2020; Kew & Tasir, 2021).

Problem Statement

The problem is that middle school students are disengaging from virtual learning. Without the advantage of in-person contact, online students run a greater risk of disengagement which leads to decreased learning and lower academic performance (Beck et al., 2022; Ford, 2022). This was especially exacerbated after the COVID-19 pandemic showcased the

deficiencies within online learning (Carter et al., 2020). Cognitive overload is among the leading causes of student disengagement along with behavioral, emotional, and social reasons (Bergdahl et al., 2020; Wang et al., 2019a). According to Sweller (2020), teachers and instructional designers can alleviate mental burden by manipulating the balance of cognitive architecture: extraneous cognitive load, germane cognitive load, and intrinsic cognitive load. Engaged learning is the active investment of mental effort in order to fulfill an instructional design task; therefore, cognitive disengagement can be a predictor of learning achievement (Kew & Tasir, 2021; Krieglstein et al., 2022a). Luckily, there are simple and effective learning strategies that can be implemented within virtual education to combat cognitive disengagement. Signaling is a thoroughly vetted best practice multimedia strategy that can enhance learning (Alpizar et al., 2020; Beege et al., 2021; Fiorella, 2022). Learning is optimized through the process of cueing (or directing) the reader toward what is essential and distinguishing what is irrelevant (Eitel et al., 2020; Fiorella et al., 2020).

The aim of this study was to supplement the current research by fulfilling a gap in the literature through the understanding of cognitive disengagement as perceived by virtual middle school students. Since the global COVID-19 pandemic, there has been a rise in online education attendance, yet research on virtual charter schools remains limited (Ford, 2022). While cognitive load has been extensively explored, impacts and refined measurements of cognitive disengagement are additional gaps in the literature (Wang et al., 2019a). Similarly, signaling has been proven to enrich learning; although, the research does not indicate what type of cueing is perceived as most influential against cognitive disengagement (Alpizar et al., 2020; Beege et al., 2021). Furthermore, the middle school students were selected as the targeted participant age due to the absence of their perspective. Typically, signaling research has been investigated at the

secondary or post-secondary levels (Arslan-Ari & Ari, 2021; Beege et al., 2021; Bolkan & Goodboy, 2020).

Purpose Statement

The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. At this stage in the research, cognitive disengagement will be generally defined as inhibited learning due to limitations in mental capacity or processing (Andersen & Makransky, 2020). Additionally, signaling will be generally defined as cues that direct learning toward critical information (Arslan-Ari & Ari, 2021). While there are many types of asynchronous learning, this study focused on virtual education as opposed to distance learning (Barbour, 2022).

Significance of the Study

Virtual learning will continue to expand, and quality instruction is necessary to empower the next generation of global citizens (Andersen & Makransky, 2020; Xiao et al., 2020). The research that was conducted is significant for filling a critical gap in understanding the cause of cognitive disengagement. As online education continues to become more individualized, engagement likewise becomes more critical (Almasseri & AlHojailan, 2019; Bergdahl et al., 2020). Among the various types, cognitive engagement is less studied due to the difficulty in measurement and the only type directly associated with learner satisfaction (Wang, 2021; Xiao et al., 2020).

Theoretical Significance

Utilizing CLT and CTML as the theoretical framework was significant for this study. CLT and CTML operate on three assumptions that are critical for addressing the problem and fulfilling the purpose. Cognitive disengagement can be reduced through the distribution of cognitive load across dual processing channels (Krieglstein et al., 2022b; Sweller et al., 1998). This study supported the positive learning correlation when auditory and visual modality is utilized. As working memory has a limited capacity, cognitive architecture will need to be managed (Anmarkrud et al., 2019; Bahari, 2022). Likewise, this study focused on student-centered, active learning. As middle school students are concrete thinkers, they benefit from additional scaffolding and organized guidance (Bolkan & Goodboy, 2020; Piaget, 1964; Schunk, 2016). The goal of this research was to contribute further understanding of cognitive engagement through the direct perspectives of virtual middle school students.

Empirical Significance

The empirical significance of this study lies in its qualitative approach and fulfillment of the research gaps. While the majority of cognitive engagement and signaling research analyzes quantitatively, this study captured the research's gap of human reflection through a qualitative transcendental phenomenological approach (Doherty, 2022; Klepsch & Seufert, 2020; Mayer, 1999, 2014, 2017; Moustakas, 1994; Xu et al., 2021). Previous qualitative studies emphasized emotional or behavioral engagement (Thuruthel & Tungol, 2021; Wang et al., 2019a). The other types of engagement have been thoroughly vetted, yet causes of cognitive disengagement remain a critical topic in prevention of student dropout (Bağriacik & Karataş, 2022). Furthermore, signaling has been verified as a best practice strategy that can combat cognitive disengagement as cues can hone learner attention to imperative information only (Bolkan & Goodboy, 2020;

Eitel et al., 2020; Ginns et al., 2020; Ring et al., 2021). Therefore, this study aimed to address the gap in the literature pertaining to which method of signaling is perceived by virtual middle school students as effective (Alpizar et al., 2020).

Practical Significance

Along with supporting the underrepresented middle school population, the practical significance of this study lies within its virtual location. Education has transformed as a result of the COVID-19 pandemic, and engagement across a digital device is more vital as online learning continues to rise (Almasseri & AlHojailan, 2019; Andersen & Makransky, 2020; Barbour, 2022; Domina et al., 2021). The use of technology on a daily basis does not constitute proficiency (Bergdahl et al., 2020). Virtual middle school students need to be willing and skilled in navigating digital learning platforms and controlling their cognitive processes (Beck et al., 2022; Beldarrain, 2006; Eitel et al., 2020). Today's 21st century learners prefer multimedia options (gamification, simulations, and virtual reality) and expect teachers to be digitally proficient (Abraham et al., 2022; Beldarrain, 2006; Eden et al., 2022). In order to combat inactive learning, educators need to understand the perceived causes of cognitive disengagement and influences of signaling (Agustini et al., 2022).

Research Questions

Virtual learners are more susceptible to cognitive disengagement due to the nature of their independent learning environment (Carter et al., 2020). Learning can be optimized through proper instructional techniques that support sensory input, working memory processing, or long-term memory storage (Anmarkrud et al., 2019; Skulmowski & Xu, 2022; Sweller et al., 2019; Webb et al., 2022). Signaling has been extensively verified in optimizing working memory because cues direct learner attention; thus, cognitive architecture is balanced not to exceed

mental capacity (Albus et al., 2021; Almasseri & AlHojailan, 2019; Mayer, 2017). However, there is a gap in the literature regarding understanding the cause of cognitive disengagement and the preventative capacity of signaling in virtual learning (Alpizar et al., 2020; Jopling et al., 2021). Therefore, the research questions for this study were as follows:

Central Research Question

What are the lived experiences of virtual middle school students during cognitive disengagement and signaling?

Sub-Question One

What are the perceived causes of cognitive disengagement in virtual middle school students?

Sub-Question Two

How do middle school students describe the influence of signaling on cognitive disengagement in virtual learning?

Sub-Question Three

What type of signaling (if any) is perceived by middle school students as most effective in virtual learning?

Definitions

1. *Automation* – the unconscious processing of information or execution of a task in which working memory is bypassed through the organization of schema (Magana et al., 2022; Sweller et al., 1998).
2. *Cognitive architecture* – the dynamics of the human brain that undergo the learning process made of working memory (short-term memory) and long-term memory. Working memory is assumed to be limited, considered active learning, and contains three

components (extraneous, intrinsic, and germane cognitive loads). Long-term memory has an unlimited capacity, is organized by schemas, and operates on various levels of automaticity (Sweller et al., 1998).

3. *Cognitive disengagement* – the mental disconnection from the activity or learning (Jopling et al., 2021).
4. *Cognitive load theory (CLT)* – explains how instructional design can optimize learning through the balancing of the three cognitive loads of working memory: extraneous, intrinsic, and germane (Sweller, 1988; Sweller et al., 1998). CLT is one of the theoretical frameworks of this study.
5. *Cognitive theory of multimedia learning (CTML)* – explains how learning can be increased through the combination of words (written or verbal) and visuals (static or motion) (Mayer, 2017; Mayer et al., 1996). CTML operates on three assumptions. Sensory information is taken in through dual process channels (auditory and visual). Working memory has a limited capacity, and students are intrinsically motivated to actively learn (Arslan-Ari & Ari, 2021; Mayer, 2017).
6. *Element* – a concept or procedure that represents what needs to be learned (Krieglstein et al., 2022b; Sweller, 2011).
7. *Extraneous cognitive load (ECL)* – task irrelevant information that is processed in working memory unproductive to the understanding of the learning material (Altmeyer et al., 2020; Sweller et al., 1998).
8. *Germane cognitive load (GCL)* – the transitional portion of working memory dedicated to schema formation through the combination of new information with prior knowledge and

the organization into long-term memory (Bahari, 2022; Beege et al., 2021; Sweller et al., 1998).

9. *Intrinsic cognitive load (ICL)* – the productive learning material itself that is processed in working memory and impacted by task complexity and prior knowledge (Bahari, 2022; Beege et al., 2021; Sweller et al., 1998).
10. *Schema* – a structure housed in long-term memory that is a compilation of multiple concepts understood together as one entity (Sweller, 1988).
11. *Self-Regulated Learning* – a motivated learner who is determined to achieve academically (Carter et al., 2020).

Summary

Since education has expanded onto the virtual platform, middle school students have struggled with disengagement in online learning (Asim et al., 2020). Among the leading causes, cognitive disengagement continues to be an understudied phenomenon that is impeding the success of intrinsically motivated scholars (Wang, 2021). Virtual education requires the highest form of cognitive engagement due to the student-centered nature (Agustini et al., 2022). Despite this learner-center approach, the responsibility of engagement falls on virtual educators (Almasseri & AlHojailan, 2019; Eden et al., 2022). Today's 21st century learners embrace a variety of technology in their daily lives and expect virtual educators to be proficient in integrating best multimedia strategies (Asim et al., 2020). Instructional designers and educators can optimize learning by balancing cognitive loads through the direction of learner attention (Sentz et al., 2019). While signaling is a proven best practice strategy, the implementation or success of specific cueing has yet to be investigated (Beege et al., 2021). The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school

students leveraging signaling to combat cognitive disengagement in virtual learning. Successful completion of this study resulted in critical insights on perceived causes of cognitive disengagement and potential solutions to improve online instructional design and thus, decrease virtual school dropout.

CHAPTER TWO: LITERATURE REVIEW

Overview

A systematic review of the literature was conducted to explore how signaling influences the engagement in virtual middle school students necessary for increased retention. Among the causes of disengagement, cognitive overload is an understudied phenomenon that could be combated through the utilization of signaling. This chapter offers a review of the research on this topic. The cognitive load theory and cognitive theory of multimedia learning are discussed in the first section, followed by a review of recent literature on the dynamics of online learning, the manipulation of cognitive architecture, and the effectiveness of signaling. The literature surrounding retention barriers for virtual school scholars are discussed. Finally, a gap in the literature was identified that there needs to be more research on middle school students' perceptions and knowledge related to online disengagement and how signaling influences cognitive overload.

Theoretical Framework

Cognitive load theory (Sweller, 1988, 2011, 2020; Sweller et al., 1998, 2019) and the cognitive theory of multimedia learning (Clark & Mayer, 2016; Mayer, 1999, 2014, 2017; Mayer et al., 1996) are logical foundational theories in order to explore how signaling can be used to prevent cognitive disengagement in virtual middle school student learning. As this study was set on the online platform, both CLT and CTML were required (Alpizar et al., 2020). While CLT explains *why* cognitive overload occurs, CTML provides *how,* yet both theories are targeted to improve instructional design (Alpizar et al., 2020; Andersen & Makransky, 2020; Eitel et al., 2020).

Sweller (1988, 2011, 2020) crafted cognitive load theory (CLT) to explain how the brain transforms information processing into learning. While CLT itself was not explicitly addressed in Sweller's (1988) study, the foundation of cognitive structure was established through the investigation of problem-solving. Learning begins with people taking in environmental stimuli through their senses, then this information is actively processed in working memory (also known as short-term memory) and compared with information stored in long-term memory (Dirksen, 2016; Larson & Lockee, 2014; Sweller, 1988, 2011; Sweller et al., 1998, 2011). Long-term memory information is referred to as prior knowledge and is organized into schemas (Krieglstein et al., 2022a; Sweller et al., 1998).

The core of CLT is schema acquisition (Sweller, 1988; Sweller et al., 1998). Schemas are bundles of information that can be understood as one concept; additionally, more schemas equate to higher expertise because long-term memory has an unlimited carrying capacity (Sweller et al., 1998). While schemas are complex or multifaceted concepts, they are processed as one unit thus alleviating working memory's limited capacity (Anmarkrud et al., 2019; Bahari, 2022; Sweller, 2011; Sweller et al., 1998). Consequently, CLT excogitates that successful learning is building schema (Magana et al., 2022).

According to Sweller (1988, 2011, 2020), mental processing efforts deplete as time progresses. Furthermore, this can be exacerbated by increasing the complexity of the task (Andersen & Makransky, 2020; Sweller, 1988). Likewise, prior knowledge impacts how draining the content is on the learner (Feldon et al., 2019; Krieglstein et al., 2022b; Sweller et al., 1998). Optimal learning is accomplished through the careful orchestration of the three cognitive load types: extraneous, germane, and intrinsic (Larson & Lockee, 2014; Schroeder & Cenkci, 2018; Sweller, 2011; Sweller et al., 1998).

By understanding how cognitive architecture impacts learning, educators can dynamically prevent disengagement. Extraneous cognitive load is the processing of the whole picture; therefore, this can be best controlled in teaching (Altmeyer et al., 2020). Rigorous learning occurs when students can segregate unnecessary or irrelevant information from the core comprehension (Makransky et al., 2019; Schroeder & Cenkci, 2018; Sweller, 1988, 2011; Sweller et al., 1998, 2011). According to Sweller (1988, 2011, 2020), organization is key to the cognitive architecture system. Germane cognitive load is steadfast in processing these organized schemas required for working memory to enter the realm of learning (Altmeyer et al., 2020). Intrinsic cognitive load deals with the complexity of the required knowledge, or prior knowledge of a specific topic, rather than the delivery (Altmeyer et al., 2020; Schroeder & Cenkci, 2018; Sweller, 1988, 2011). Ample research can already be found for testing low and high prior knowledge (Makransky et al., 2019; Richter & Scheiter, 2019).

The cognitive theory of multimedia learning (CTML) is an inseparable companion to cognitive load theory, especially for digital learning (Clark & Mayer, 2016; Mayer, 1999, 2014, 2017; Mayer et al., 1996). As evident in their compatible names, the cognitive theory of multimedia learning has developed based on extensive research into applying the cognitive load theory (Anmarkrud et al., 2019). Grounded on Sweller's (1988) CLT research, CTML was established as an extension of three principles: split-attention, dual-processing, and redundancy. Split-attention impacts spatial contiguity, which influences extraneous and intrinsic cognitive load (Altmeyer et al., 2020; Makransky et al., 2019; Moon et al., 2022, Schroeder & Cenkci, 2018; Sweller, 2020; Wu et al., 2018). When spoken words are combined with visual imagery, dual processing is employed, and learning is optimized (Fiorella et al., 2020; Knoster & Goodboy, 2023). On the other hand, redundancy occurs when the spoken narration coincides

with the visual imagery, resulting in decreased learning due to increasing extraneous cognitive load (Clark & Mayer, 2016; Mayer, 1999; Mayer et al., 1996; Sweller, 1988, 2011). In essence, CTML capitulates that intrinsically motivated students learn better when graphics and texts are combined because they do not overload one sensory pathway (Altmeyer et al., 2020; Clark & Mayer, 2016; Makransky et al., 2019; Mayer, 1999, 2014, 2017; Mayer et al., 1996; Sweller, 2020).

Among the surfeit research combinations of graphical and textual learning, signaling is a best practice strategy in which educators direct students' attention (Arslan-Ari & Ari, 2021; Fiorella et al., 2020; Knoster & Goodboy, 2023; Paek et al., 2017). Signaling is highly effective due to its ability to decrease extraneous cognitive load, reinforce germane cognitive load, and streamline intrinsic cognitive load (Glaser & Schwan, 2020; Richter & Scheiter, 2019; Richter et al., 2018; Xie et al., 2018). Therefore, the gap in the literature is in the indication of where and how students cognitively disengage. Knowing the causes of disengagement from overloading cognitive architecture will be valuable for educators, instructional designers, and learners.

Related Literature

Learning is an important and sometimes complex phenomenon due to different learning preferences and environments. In this Age of Technology, education has expanded in a multifaceted way, particularly after the COVID-19 global pandemic (Beck et al., 2022; Fiorella, 2022). For instance, multimedia use (such as signaling and dynamic videos) accelerated during the pandemic (Adedoyin & Soykan, 2023; Cojean & Jamet, 2021; Doherty, 2022; Fiorella, 2022). While people have a variety of ways that they ideally absorb information, human cognitive architecture is fundamentally the same (Sweller, 2011). The following related literature illustrates the context of online learning. Due to its nature, virtual schools experience higher

levels of cognitive disengagement, which can reduce student retention (Beck & Beasley, 2021; Toppin & Toppin, 2016). However, this can be mitigated through the optimized manipulation of cognitive architecture by using the best practice multimedia strategy of signaling (Alpizar et al., 2020; Giordano & Christopher, 2020; Mayer et al., 2020). Literature related to virtual learning disengagement, cognitive architecture optimization, and the use of signaling were investigated in this section.

Online Learning

Education is in the business of preparing students to become productive members of a global society (Montero-Sieburth & Turcatti, 2022). Consequently, student retention through the maintenance of engagement is significant (Piscitello et al., 2022). On the one hand, technology offers new prospects for learning explorations (Skulmowski & Xu, 2022). Although, technology can also add another element of complexity to the learning process (Beck et al., 2022; Chang et al., 2020). There are various levels of digital incorporation. Technology-Enhanced Learning (TEL) and Quantum Flipped Learning (QFL) have been used in brick-and-mortar settings to incorporate digital devices such as Chromebooks (Agustini et al., 2022; Bergdahl et al., 2020). More common at the post-secondary level, hybrid models are employed to supplement in-person, synchronous learning. Hybrid has also been called blended or mixed learning due to the combination of synchronous and asynchronous methods (Xiao et al., 2020).

While these models of technology-integration can be considered online learning, they are not the focus because ample research has investigated those structures. This study addressed the gap in the literature which involves virtual school learning. Virtual schools are distinctive as students have the ability to learn anytime and anywhere (typically) with a family member as their main Learning Coach (Barbour, 2022; Mayer, 2017). Without the luxury of physical presence, it

becomes even more critical for virtual educators and instructional designers to utilize best practice strategies in order to engage online learners (Bahari, 2022). The effectiveness of signaling on cognitive architecture can be more readily appreciated by first distinguishing the types of asynchronous learning and understanding the types of online engagement.

Types of Asynchronous Learning

Educational technologies have the capability to enhance student rapid interactions and develop their responses to real-world challenges; however, not all online learning is created equal (Lopez-Caudana et al., 2022). Massive open online courses (MOOCs) is a general term used typically at the collegiate level (Cojean & Jamet, 2021; Pi et al., 2021; Stöhr et al., 2019; Stull et al., 2021). Skulmowski and Xu (2022) used digital learning and technology-enhanced learning interchangeably with e-learning. Most virtual learning systems are named according to their intended purpose. For example, Bağriacik and Karataş (2022) referred to virtual learning in an all-encompassing term called online and distance education (ODE); additionally, Pratama and Firmansyah (2021) defined distance learning as learning from home (LFH). In contrast, Beck et al. (2022) utilized the more traditional phrasing of cyber school.

When the COVID-19 pandemic occurred, the virtual education platform changed expansively (Carillo & Flores, 2020; Knoster & Goodboy, 2023). For example, ODE and LFH went into effect across the globe (Bağriacik & Karataş, 2022; Pratama & Firmansyah, 2021). Unfortunately, this unprecedented shift resulted in “pandemic pedagogy” in which the curriculum was constructed for short-term survival rather than rigor (Barbour, 2022, p. 351; Gouseti, 2021, p. 2). The new isolation and independent learning resurrected self-regulated learning (SRL) as the development of metacognitive skills meant to maintain academic performance (Carter et al., 2020). In contrast, not all schools were in survival mode during the

pandemic. Valor Global has been renowned as an effective virtual school due to its well-established history and private educational model that internationally serves students in grades 2-12 (Beck et al., 2022). Bağriacik and Karataş (2022) explained that distinguishing the types of asynchronous learning is essential in order to understand the framework for the research.

In alignment with Mayer's (1999, 2014, 2017) cognitive theory of multimedia learning (CTML) theoretical framework, virtual or e-learning operates on the assumption that students are intrinsically driven, resulting in active learning. Likewise, Sweller's (1988, 2011, 2020) cognitive load theory (CLT) theoretical framework has the purpose of enhancing instructional design to meet the needs of these learners. Educational technology must fuse with best practice to optimize cognitive architecture in order to elevate learning (Sweller, 2020). Virtual educators not only need to know how to engage today's 21st century learners but also prevent cognitive disengagement. Appropriately employing multimedia strategies (such as signaling) can lessen the burden of working memory's capacity to keep learners engaged (Mayer, 2017; Sweller, 2020).

Virtual Engagement

Without the advantage of in-person contact, online learning requires specific forms of intentional engagement. According to the adolescent community of engagement (ACE) model, there are three main types of engagement in which students expend their energy to complete learning activities: affective (or emotional), behavioral, and cognitive (Beck et al., 2022; Piscitello et al., 2022). Cognitive engagement has a strong correlation with academic achievement (Xie et al., 2020). Wang et al. (2019a) presented the inclusion of social engagement as a fourth type due to the profound influence of community on success. Although, social engagement is typically excluded as the aforementioned three types are deemed more

straightforward to observe (Bergdahl et al., 2020), essential for more profound levels of learning (Henrie et al., 2018), and more likely to be adversely impacted (Thuruthel & Tungol, 2021). After the COVID-19 pandemic, social engagement held greater influence (Piscitello et al., 2022).

Contrary to the dropout prediction, rural Columbia saw higher disengagement in virtual schools due to economic and social pressures rather than curriculum inadequacies (Rincón et al., 2021). According to Seymour et al. (2020), the achievement gap expanded during the COVID-19 pandemic due to inequities in circumstance. Students in low-income and split-family situations were more susceptible to not having necessary digital resources or designated study space (Seymour et al., 2020). Moreover, the social isolation negatively affected mental health which inadvertently led to cognitive disengagement through deterred motivation (Gouseti, 2021). In contrast, China viewed the pandemic's educational impact as a trial to examine the resolve of online learning (Zhong & Lyu, 2022)

Understanding these types of engagement is critical so that virtual educators know how to support students when they disengage (Barbour, 2022; Beck et al., 2022). When faced with engagement or technology difficulties, students are more likely to ask peers, parents, and then teachers (respectively) for support (Bergdahl et al., 2020). Beck et al.'s (2022) case study corroborated as advocates (non-instructional, homeroom teachers) self-reported having higher confidence and being more effective with supporting behavioral and emotional disengagement over cognitive disengagement. Consequently, this puts significant responsibility on virtual educators to optimize the management of cognitive engagement.

The 21st Century Brain

Learning and mental processing continue to evolve as a consequence of technologies' integration (Anmarkrud et al., 2019; Skulmowski & Rey, 2020); although, Wilson et al. (2017)

indicated that (contrary to popular belief) research does not support the degradation of mental capacity due to technology. The purpose of education is more than knowledge acquisition but also the development of critical thinking and digital literacy (Tugtekin & Odabasi, 2022). While mental capacity and duration have limitations, the components involved in processing can be streamlined to maximize learning (Sweller, 1988, 2020; Sweller et al., 2019). Both the quantity and characteristics of the components (or elements) will influence how the brain processes the new information (Beege et al., 2021).

How Learning is Processed

There are three distinct arenas in which information travels to constitute learning: the sensory systems, the working memory, and the long-term memory (Tugtekin & Odabasi, 2022). The systematic processing of information begins with the acquisition of environmental stimuli (Mayer, 2017; Paek et al., 2017). External information is analyzed in working memory by comparing the new knowledge to prior knowledge housed in long-term memory (Beege et al., 2021; Sweller, 1988, 2011). Information deemed relevant or valuable to the individual is ultimately stored in long-term memory for later recollection (Bahari, 2022; Kahlil & Elkhider, 2016; Larson & Lockee, 2014). A critical distinction for this research is the capacities of the cognitive system. Sweller (1988, 2011, 2020) indicated that working memory has a limited capacity; however, Bahari (2022) expressed that long-term memory is unlimited. Therefore, the focus of education is to optimize working memory processing and convert as much information into long-term memory as possible.

The foundation of cognitive architecture is biological knowledge (Geary, 2002; Geary & Berch, 2016). Through the review of cognitive evolution and educational psychology, Geary (2002) found that human knowledge can be categorized into two distinct factors: biological

primary knowledge or “folk knowledge” and biological secondary knowledge or “academic competencies” (p. 328). Primary knowledge development has been an evolutionary process as this type cannot be explicitly taught (Ginns et al., 2020; Skulmowski & Xu, 2022; Sweller et al., 2019). Collaboration, facial recognition, native language speaking, and movement are examples of primary knowledge (Ginns et al., 2020; Paas & van Merriënboer, 2020; Sweller et al., 2019). On the other hand, biological secondary knowledge requires instruction because it involves skills such as reading and writing (Geary, 2002; Ginns et al., 2020; Paas & van Merriënboer, 2020; Sweller, 2020; Sweller et al., 2019).

Cognitive performance is dependent on effective development of both types of biological knowledge (Geary, 2002). Secondary knowledge is dependent on cultural influence as defined by primary knowledge (Sweller, 2011). Without the self-motivation or foundational skills of primary knowledge, acquisition of biological secondary knowledge would be difficult to obtain (Geary & Berch, 2016; Ginns et al., 2020; Sweller et al., 2019). In fact, Sweller (2011) expressed that secondary knowledge cannot be gained through observations. This means that contrary to the automation of primary knowledge (Sweller et al., 2019), secondary knowledge requires conscious effort to prevent cognitive disengagement in order to maintain actively learning (Paas & van Merriënboer, 2020; Skulmowski & Xu, 2022; Sweller, 2020). Furthermore, Geary (2002) warned that technology has created a gap between primary and secondary knowledge; thus, direct instruction is necessary in such cases as virtual learning. For these reasons, primary knowledge may not impact working memory’s limited capacity while secondary knowledge could cause cognitive overload (Paas & van Merriënboer, 2020).

Cognitive architecture refers to the three cognitive loads used in working memory that actively process different inputs (Sweller et al., 2019). Cognitive load theory refers to these loads

as extraneous (ECL), germane (GCL), and intrinsic (ICL) (Sweller, 2011, 2020; Sweller et al., 1998). On the other hand, CTML replaces ICL with essential and GCL with generative (Alpizar et al., 2020; Mayer, 1999, 2014, 2017). The three cognitive loads are usually presented in the order in which they affect working memory and promote retention: ICL, ECL, and GCL (Bolkan & Goodboy, 2020).

Intrinsic or essential cognitive load (ICL) precedes the others because this represents the material or elements that require learning (Beege et al., 2021; Sweller et al., 1998). Known as the productive load, ICL relates to the essential processing of working memory devoted to analyzing the elements (Beege et al., 2021; Doherty, 2022; Krieglstein et al., 2022b; Makransky et al., 2019; Sweller, 2011; Sweller et al., 1998). Elements are defined as what needs to be learned or the content itself (Beege et al., 2021; Sweller et al., 1998). Typically, ICL is measured based on the number of elements that are simultaneously being processed by working memory (Ginns et al., 2020; Krieglstein et al., 2022a; Makransky et al., 2019).

The amount of work memory capacity that will be consumed by intrinsic cognitive load is influenced by the learning goal, complexity of content, and individual's knowledge level (Magana et al., 2022). In other words, complexity and ICL will increase with more elements involved in the content being simultaneously processed (Huh et al., 2019; Krieglstein et al., 2022b; Sweller, 2011). Learning goals can either have low element interactivity or high element interactivity. Memorizing chemical symbols and their corresponding names would be an example of low element interactivity (Sweller et al., 1998). On the other hand, learning vocabulary along with the grammar necessary to understand an article would results in high element interactivity (Beege et al., 2021). The latter is congruent with high ICL due to the increased cognitive strain required for processing (Beege et al., 2021; Sweller et al., 1998).

Complexity of content and knowledge level distinguish the proficiency of the learner (Novak & Schwan, 2021). Although, Krieglstein et al. (2022b) utilized complexity of tasks synonymously with element interactivity. In contrast, the complexity of the task can either be measured by how many components there are required to learn (Sweller, 1988) or the perceived complexity of the task by the learner (Andersen & Makransky, 2020). Furthermore, complexity of task is linked to prior knowledge (Alpizar et al., 2020; Beege et al., 2021; Eitel et al., 2020; Krieglstein et al., 2022a; Magana et al., 2022; Richter & Scheiter, 2019). More prior knowledge on a given topic equates to lower intrinsic cognitive load because more schemas have been formed (Sweller et al., 1998). Likewise, more schemas (or chunked elements) are associated with higher expertise (Huh et al., 2019).

Appropriately named, extraneous cognitive load (ECL) is frequently seen as the archnemesis of effective learning because it consumes valuable energy, focus, and capacity (Gonçalves et al., 2022; Sweller, 2011). ECL tends to be a focal point for educators to reduce or eliminate because the information being processed is deemed extraneous, irrelevant, or unnecessary (Alpizar et al., 2020; Miller et al., 2020; Richter & Scheiter, 2019; Richter et al., 2018). Unique to ECL, instructional design can change the amount of working memory consumed by this cognitive load (Skulmowski & Rey, 2020; Sweller et al., 2011). Notwithstanding, inadequate learning material may induce unnecessary processing (Richter & Scheiter, 2019). Contrary to intrinsic, teachers can fully exploit ECL; therefore, irrelevant and unproductive stimuli need to be mitigated as much as possible (Almasseri & AlHojailan, 2019; Altmeyer et al., 2020; Beege et al., 2021). Non-optimal spatial or temporal designs can lead to soliciting inappropriate information, thus extraneous cognitive load will increase and mental capacity will be consumed (Huh et al., 2019; Krieglstein et al., 2022b; Mayer, 2017).

Educational technology such as simulations and videogames have a predisposition to increase ECL since learners need to process both the system and content (Magana et al., 2022; Sweller, 2020).

Germane or generative cognitive load is less frequently addressed than the other types because it resides as the pinnacle connector between working and long-term memory (Altmeyer et al., 2020; Bahari, 2022). Germane cognitive load packages the relevant information into schema (or organized structures) to be stored within long-term memory (Alpizar et al., 2020; Bahari, 2022; Beege et al., 2021; Sweller et al., 2011). Schema are created by synthesizing new information and expounding upon the already structured prior knowledge housed in long-term memory (Alpizar et al., 2020; Huh et al., 2019).

Out of the three cognitive structures, germane is the most debated (Anmarkrud et al., 2019). According to Krieglstein et al. (2022a), GCL is the only productive load. Likewise, germane cognitive load has been touted as most important because of its fulfillment of CLT's learning purpose of schema building (Miller et al., 2020; Sweller et al., 1998; Zu et al., 2020). In other words, GCL is the critical component in which new knowledge gained from the active learning process within working memory translates into achieved long-term memory comprehension (Chang et al., 2020; Skulmowski & Xu, 2022). The germane cognitive load bridges working memory resources to long-term memory storage (Miller et al., 2020). GCL is particularly important to the learning process as working memory is limited in capacity and duration while long-term memory is not (Andersen & Makransky, 2020).

The identity of the germane cognitive load is controversial (Greenberg & Zheng, 2023; Skulmowski & Xu, 2022). On the one hand, GCL processes the intrinsic cognitive load into these schemas and (similar to extraneous) can be influenced by instructional design or student

motivation (Magana et al., 2022). In contrast, GCL has been equated to the sum of subtracting ECL from ICL (Eitel et al., 2020). Ironically, GCL was later eliminated from the original theorist's research (Sweller, 2011, 2020), yet Zu et al. (2020) made one of their research goals to validate the existence of all three load types through physiological measurement (eye motion). Rodemer et al. (2022) explained that GCL does not contribute to the overall total cognitive load; therefore, the functions of germane have been reallocated to ICL and ECL. Unlike the other cognitive loads, GCL is exclusively influenced internally (Anmarkrud et al., 2019). Ginns et al. (2020) argued that intrinsic and germane are indiscernible, so the inclusion of GCL is redundant. On the other hand, GCL is replaced by ICL due to their shared dependence on knowledge level and influence by element interactivity (Alpizar et al., 2020; Krieglstein et al., 2022b).

The amalgam of the three cognitive loads determines if a learner is an expert or novice at a given subject. Experts have more schemas; therefore, they have more prior knowledge in larger chunks (Sweller, 1988). According to Sweller et al. (1998), working memory can process up to seven elements before reaching cognitive overload. High complexity substantially reduces the processing power causing working memory to only handle two to three elements (Sweller et al., 1998). An expert already has extensive repertoire of highly complex elements chunked together into schemas (Magana et al., 2022; Sweller et al., 1998). Conversely, novices will chunk information in smaller amounts (Sweller, 1988). The reduction of ICL and increase of GCL distinguishes the expert from the novice (Ginns et al., 2020; Huh et al., 2019).

Manipulating Cognitive Architecture

Cognitive load theory (CLT) is at the core of multimedia learning as it explains how information is processed and stored (Anmarkrud et al., 2019); hence, the cognitive theory of multimedia learning (CTML) guides how instructional design can influence learning (Alpizar et

al., 2020;). This is grounded on the theories' main assumptions. Learning begins when environmental stimuli are taken in through dual (visual and auditory) processing channels (Guo et al., 2020; Mayer, 2017). Both, CLT and CTML assume that working memory has a limited capacity and duration (Andersen & Makransky, 2020; Glaser & Schwan, 2020; Mayer, 2017; Schroeder & Cenkci, 2018; Sweller, 2020). Thirdly, active learning is defined as selecting, organizing, and integrating new information with prior knowledge (Alpizar et al., 2020; Altmeyer et al., 2020). Additionally, Sweller et al. (1998) encouraged instructional designers to have a rich understanding of CLT dynamics.

Once an educator has a foundational understanding of how students learn, the variables in cognitive architecture can be manipulated to optimize learning (Mayer, 2017). First, instructional designers can streamline the external stimuli going into working memory. For example, the modality effect indicates a better learning experience if both visual and auditory processing channels are used to reduce the strain on one system (Sweller, 2020). This is why multimedia learning dynamics are particularly effective as they utilize dual processing (Mayer, 2017; Paek et al., 2017). As the name suggests, multimedia combines visuals and text intentionally to avoid overloading one channel (Altan & Cagiltay, 2022). Multimedia can encompass sources such as physical textbooks (Rodemer et al., 2022) or online videos (Mayer et al., 2020). Although, Almasseri and AlHojailan (2019) warned that virtual products can take more mental capacity due to the higher sophistication of work required.

Another way to enhance learning through the construction of cognitive architecture is addressing working memory directly. The capacity of active learning comes from the allocation of mental resources to complete a specific task (Larmuseau et al., 2020). While working memory has a temporary storage duration and limited capacity, there are ways for the learner to guide

these variables (Moon et al., 2022). Reducing the burden of the learning task can decrease mental processing (Skulmowski & Xu, 2022). In contrast, if the learning is highly complex in detail or contain numerous action steps, then maximum cognitive capacity will be reached quickly (Rodemer et al., 2022). Paas and van Merriënboer (2020) capitulated that simple tasks are negligible to the limits of working memory. Furthermore, confusion and misconceptions will lead to mental process depletion (Rodemer et al., 2022).

Environment may also influence the effectiveness of active learning (Gnesdilow & Puntambekar, 2022; Sweller, 2020; Sweller et al., 2019). Both physical and digital environments can subjugate working memory; hence, the importance of intentional educator control is paramount (Beeman, 2022). According to Fisher et al. (2014) physically cluttered environments can lead to diminished skills performance. Similarly, immersive technology such as augmented and virtual realities can rapidly consume working memory's capacity due to the bombardment of visuals and auditory dynamics (Albus et al., 2021; Chang et al., 2020; Gouseti, 2021; Skulmowski & Xu, 2022). Moreover, the integration of haptics (touch) sensory in virtual reality can lead to cognitive overload because the learner may be over stimulated (Webb et al., 2022).

Cognitive capacity can be restored or enhanced as well. For example, the simple act of resting one's eyes or disengaging from the screen for a period of time can reinstate working memory's processing capabilities (Paas & van Merriënboer, 2020; Sweller, 2020). Cognitive capacity can also be expanded through collaboration as learners can share the burden of the task at hand. In other words, no one person risks cognitive overload in collaborative scenarios because the threshold is lowered among all members (Webb et al., 2022).

These environmental diminutions of active learning can be summarized in the split-attention effect. This occurs when the task requires understanding of components in isolation, yet

learners are forced to process multiple dynamics concomitantly (Mayer, 2017; Moon et al., 2022; Sweller, 2020). Multimedia learning can induce split-attention through spatial distance or video timing (Mayer et al., 2020; Paas & van Merriënboer, 2020). For example, visuals can be segregated from on-screen text or auditory narration can be mismatched from visual cues (Mayer, 1999). Additionally, unfamiliarity with an educational platform can lead to the consumption of working memory's limited capacity; thus, content learning will not be achieved (Bahari, 2022). Consumption can be caused by several reasons. Navigating technical glitches or toggling between two web browser tabs can disconnect the learner from on-task performance (Chang et al., 2020; Miller et al., 2020). Temporal contiguity can also be negatively impacted if the content is shown in a simultaneous fashion rather than successively (Rodemer et al., 2022).

Ensuring contiguity between working memory and long-term memory is the final component of cognitive architecture that can be manipulated. Although, educators can scaffold the learning to help students construct schemas that will increase ICL and GCL while decreasing ECL (Mutlu-Bayraktar et al., 2019). Instructor clarity is critical to prevent cognitive overload and streamline logical processing (Bolkan & Goodboy, 2020). Organized schemas will also help students obtain the ultimate learning objective of transferring said information into long-term memory (Ginns et al., 2020; Wu et al., 2018).

Among the ways to balance cognitive load, the reduction of ECL is a primary target. Signaling can also combat split-attention that tends to increase extraneous processing (Eitel et al., 2020; Makransky et al., 2019; Mayer, 2017). A secondary monitor can reduce ECL for virtual learning (Miller et al., 2020). In contrast, Beege et al.'s (2021) study actively pursued the investiture of ECL; Rather than viewing ECL as a hindrance to learning, Beege et al. (2021) presented it as the gatekeeper to deeper learning. Likewise, Skulmowski (2022) embraced the

promotion of ECL in his research of realism (or realistic pictures) as a form of signaling. Critical thinking was ignited due to the rich details within the realistic visuals (Skulmowski, 2022).

Furthermore, proper instruction techniques can determine whether the information will be processed as ECL or ICL. According to Eitel et al. (2020), students can still achieve learning outcomes even with extraneous information as long as negligible content is identified. In other words, students will waste their working memory capacity to process unimportant information if they are unaware of its irrelevancy (Eitel et al., 2020). Additionally, ICL can be maintained if the levels of elements requiring mental processing are manageable (Beege et al., 2021; Sweller, 1988, 2011, 2020). A manageable number of components in ICL will lead to effectively organizing GCL (Ginns et al., 2020; Mayer, 2017).

Wang (2021) expanded cognitive engagement to include connecting and building relationships among concepts. Fostering GCL is an under-utilized strategy by instructional designers (Sentz et al., 2019). In other words, schema automation extends the longevity of working memory's duration. The goal of automation is to process the learning in an unconscious or automatic capacity as that would not deter from short-term memory processing nor deplete learner energy (Krieglstein et al., 2022a). Expert scholars who engage in deep critical thinking will yield a richer learning experience and enhance performance (Kew & Tasir, 2021).

Signaling

Signaling is one of many multimedia principles that is most effective when applied appropriately (Doherty, 2022; Knoster & Goodboy, 2023). Signaling directs learner attention to the critical information or central ideas to help them determine pertinent information that should be stored in long-term memory (Albus et al., 2021; Alpizar et al., 2020; Beege et al., 2021; Clark & Mayer, 2016; Mayer, 2017; Richter et al., 2020; Ring et al., 2021; Xie et al., 2018). When

utilized properly, signaling can enhance learners' retention and transfer in comparison to teaching without cues (Fiorella, 2022). Retention and transferability are two central pillars of learning in which students recreate or recognize the material or apply the knowledge to a new scenario, respectively (Li et al., 2022; Mayer & Fiorella, 2022). Thus, educators are able to scaffold cognitive engagement (Skulmowski & Xu, 2022). This section will explore the diverse array of signaling forms and the suitable settings that have thus far been researched.

Types of Cues

Multimedia learning is the use of multiple channels to optimize mental processing through the use of intentional direction (Cojean & Jamet, 2021; Stull et al., 2021). Signaling can be categorized as static or dynamic depending on the form of direction needed (Mayer et al., 2020; Moon et al., 2022; Rodemer et al., 2022). Static cues are typically more simplistic, pictorial forms than their dynamic counterparts (Fiorella et al., 2020). These can be found in physical and digital textbooks (Altan & Cagiltay, 2022; Rodemer et al., 2022). There are many examples of static cues such as blurring (Glaser & Schwan, 2020), bolding or coloring fonts (Alpizar et al., 2020; Beege et al., 2021; Li et al., 2022), adding illustrations (like arrows) (Rodemer et al., 2022; Xie et al., 2018), and spotlighting (Glaser & Schwan, 2020; Knoster & Goodboy, 2023).

Color signaling is the most cited form of static cues used (Almasseri & AlHojailan, 2019; Doherty, 2022; Moon et al., 2022; Rodemer et al., 2022). Highlighting's popularity resides in the definition as essential information is made to stand out through contrasting an overlaid color (Clark & Mayer, 2016; Mayer, 2017). Notably, Knoster and Goodboy (2023) expanded highlighting to include the manipulation of text color, itself. Additionally, objects or

manipulatives can be highlighted (Bone et al., 2023). Flashing or graying out the text have also been found to benefit learning (Knoster & Goodboy, 2023; Li et al., 2019).

Static cues are not limited to motionless visuals because signaling is a multimedia (video) principle (Fiorella et al., 2020; Mayer & Fiorella, 2022). On the one hand, highlighting cues have been used to encourage skill building in read along books (Arslan-Ari & Ari, 2021). Spatial contiguity (or close proximity) can be improved through a digital highlighting tool function on tests (Moon et al., 2022). On the other hand, verbal cues can be pitch or volume changes for emphasis (Alpizar et al., 2020; Clark & Mayer, 2016; Glaser & Schwan, 2020). Furthermore, step-by-step drawing animations are a method of static signaling as learning is segmented into manageable components (Mayer et al., 2020).

Dynamic signaling adds a complexity to a multimedia learning that tends to be absent from static cues (Rodemer et al., 2022). Dynamic cues typically involve an interaction or multisensory component (Mayer et al., 2020). For example, animations and action-based drawings leverage dual processing channels by providing auditory and visual representation simultaneously (Cojean & Jamet, 2021; Fiorella et al., 2020). What distinguishes dynamic animations from motioned static signals are the required interactivity of the user (Moon et al., 2022). In Moon et al.'s (2022) study, static cues were represented by constant object highlighting; moreover, dynamic signals were only revealed when the participant hovered the mouse over the correct manipulative. When dynamic signals are multisensory, historically these studies have researched visual (sight) and auditory (hearing); however, haptic (touch) has also been included (Novak & Schwan, 2021).

Along with haptic cues, instructor motion is a type of social signaling that falls under the category of embodiment (Knoster & Goodboy, 2023; Stull et al., 2021). In line with the other

types of cues, social signals direct learner attention through the use of eye contact, facial expressions, gestures, or posture (Fiorella et al., 2019, 2020; Pi et al., 2021; Rato et al., 2019). In other words, students learn how to process multimedia information through the social cue directives of the instructor (Stull et al., 2021). Additionally, instructors do not need to be human as "human-like pedagogical agents" (or animated beings) can produce the same effective guidance (Li et al., 2022, p. 621).

These social signals can be further broken into subcategories. Eye contact is highly influential on directing the learner's focus (Lanthier et al., 2019; Pi et al., 2021). According to Lanthier et al. (2022), people will fixate on eyes of a picture or video 70-80% of the time; whereas, people will avoid eye contact when in-person unless the circumstance is social. The benefit of eye fixation is a positive impact for virtual learning as multimedia use is an exclusive dynamic (Eden et al., 2022). Social cues increase cognitive engagement because learners feel more connected with the instructor; therefore, the learner puts in more effort due the instructor elevating their intrinsic motivation (Fiorella et al., 2020).

Eye contact has the ability to shape cognitive engagement (Stull et al., 2021). Direct gaze is when the instructor looks directly at the camera giving the appearance of eye contact to the learner (Pi et al., 2022). On the other hand, gaze guidance is when the instructor's eyes move towards the slides or essential information, thus the student's focus follows (Pi et al., 2020; Wang et al., 2019b). Counterintuitively, Mayer et al., (2020) identified gaze guidance as being more effective because it builds a social connection between in the instructor and student. Pi et al.'s (2020) study corroborated as gaze guidance assisted learners in spending more focal time on the relevant information (slides) over the instructor's face.

The impact of eye gaze is dependent on the other social cues in which its paired. For instance, facial expressions attune the influence of the gaze effect (Pi et al., 2022). Direct gaze will increase learning performance when paired with a happy facial expression (Pi et al., 2021; Pi et al., 2022). This is because smiling and eye contact are a form of high embodiment which leads to superior cognitive engagement (Knoster & Goodboy, 2023). Ironically, students did not notice gaze guidance unless the instructor was also using a surprised expression. The students followed the instructor's gaze out of curiosity of the surprised expression (Pi et al., 2021). In contrast, pointing gestures are more effective than gaze guidance (Li et al., 2022; Pi et al., 2019). Warm colors and face shape can also lead to eliciting positive emotions in students; thus, cognitive engagement is simultaneously enriched (Li et al., 2022).

The physical stance of the instructor is a debated social cue. Pi et al.'s (2020) study found that body orientation (frontal or lateral) had no influence on the effectiveness of eye gaze. Whereas, the posture of the instructor can change learner's cognitive engagement depending on the direction he or she is facing (Fiorella et al., 2019; Mayer et al., 2020). Likewise, learning is positively impacted when instructors used a first-person perspective rather than a third-person view as learners are enticed to actively participate (Mayer et al., 2020). First-person perspective is particularly helpful with haptic cues such as tracing (Novak & Schwan, 2021; Paas & van Merriënboer, 2020).

The final type of signaling is organization. Knoster and Goodboy (2023) made an important distinction that signaling does not add new information but rather a structure in which learner's cognitive architecture is shaped to best process the essential material. Physical textbooks utilize organizational signaling through the use of headlines and manipulating font (Cojean & Jamet, 2021; Knoster & Goodboy, 2023). Structural cues have also been replicated on

the digital platform through websites and massive open online courses (Bacca-Acosta et al., 2022; Cojean & Jamet, 2021; Stöhr et al., 2019). Virtual labs also provided organized cues by leading learners with pop-up's (Liu et al., 2022). Moreover, the number of interactive elements can influence cognitive engagement (Zu et al., 2020). Charts, concept maps, and graphic organizers are effective ways to streamline mental processing (Bacca-Acosta et al., 2022; Bahari, 2022; Krieglstein et al., 2022b).

While there is a gap in the literature of which annotated illustration is preferred, Altan and Cagiltay (2022) did find that middle school students preferred colored cues over arrows and no cues. Those results could be due to the higher complexity of dynamic signaling (Fiorella et al., 2020). Pilegard and Fiorella (2021) warned that even though signaling may be effective in managing cognitive loads, there is no guarantee that students would know how to capitalize on cue incorporation when on their own.

Empowering the Cognitive Process

Both the cognitive load theory (CLT) and the cognitive theory of multimedia learning (CTML) define learning as the creation of mental constructs (Rodemer et al., 2022). This is achieved by selecting relevant information, organizing words and picture models in working memory, and synthesizing the new information with prior knowledge into schemas stored in long-term memory (Cojean & Jamet, 2021). Therefore, there are three main areas that cognitive engagement can be optimized: multisensory channels, working memory, and schema development (Zu et al., 2020).

Dynamic signals are an influential multimedia strategy because they empower the cognitive process through the first component of utilizing multisensory channels (Cojean & Jamet, 2021; Webb et al., 2022). With the rise of technology integration, animated videos

increase the effectiveness of signaling (Rodemer et al., 2022). The duality of using sound and visuals reduces the risk of split-attention and streamlines spatial contiguity (Moon et al., 2022). However, Bacca-Acosta et al. (2022) found that static signals will also decrease split attention. When multiple sensory channels are utilized, students are able to make sense of the material faster due to one channel not being overwhelmed (Mayer, 2017). In contrast, closed captioning can slow learning (especially for secondary language learners) as students will focus on word comprehension and miss the audio (Mayer et al., 2020).

Haptic or touch sensory has been far less researched than the combination of visual and auditory channels (Novak & Schwan, 2021). When haptic has been researched, it is either paired with embodiment or learner directed activities. For example, students can dedicate a large amount of channel processing solely to reading facial expressions which can lead to detracted learning (Stull et al., 2021). Gestures by the instructor can lead to either higher learning with pointing cues (Ginns et al., 2020) or lower learning with distractive conversational cues (Moon & Ryu, 2021). On the other hand, mimicked gestures by the learner can offload mental capacity (Paas & van Merriënboer, 2020).

Because working memory's capacity is even shorter than its processing, signaling (or cueing) is a best practice strategy and effective in managing cognitive architecture (Ginns et al., 2020; Mayer, 2017; Moon et al., 2022; Sweller, 2011). In contrast, long-term memory operates at an unlimited capacity; therefore, learning aims to transverse as much information as possible into long-term storage for later recollection (Bahari, 2022). In other words, the goal of learning is to lower ECL and foster GCL (Liberman & Dubovi, 2023). For instance, searching a webpage or switching between screens can deplete working memories capacity because ECL is increased (Miller et al., 2020). Whereas, graphic organizers are a form of visual signaling that assists GCL

in accurately categorizing schemas from new information with prior knowledge (Bahari, 2022; Beege et al., 2021).

Prior knowledge is one factor that influences the effectiveness of signaling. Students with low prior knowledge tend to benefit more from signaling than those with high prior knowledge (Alpizar et al., 2020; Makransky et al., 2019; Mayer, 1999; Richter et al., 2020). For example, when using dynamic signaling (videos) over static images, students with low prior knowledge perform significantly better on retention tests (Mayer et al., 2020). Schroeder and Cenkci (2018) explained that signaling helps reinforce concepts through redundancy, increasing ICL; however, students with high prior knowledge processed the redundant information as ECL, negatively impacting their learning. On the other hand, Schneider et al. (2018) claimed that students with high prior knowledge rather than low prior knowledge benefit from signaling because knowledgeable students are better equipped with the skills to cope with the additional information provided.

Age is another factor that influences the effectiveness of signaling. Bolkan and Goodboy (2020) capitulated that signaling impacts age groups differently due to the development of concrete and abstract processing. Undergraduate students are the highest recruited demographic for signaling participation (Alpizar et al., 2020; Schroeder & Cenkci, 2018). This is logical as multimedia instruction is highly integrated at the collegiate level (Chang et al., 2020; Cojean & Jamet, 2021). On the other hand, students in elementary school have a higher distractibility which would result in inhibiting working memory; consequently, external stimuli need to be controlled (Fisher et al., 2014). While there are a handful of primary education studies for signaling effects, virtual middle school students remain an underutilized group (Albus et al., 2021; Arslan-Ari & Ari, 2021; Ginns et al., 2020; Richter et al., 2018).

Studies that employ middle school age participants were conducted in-person with technology assistance. For instance, Bone et al.'s (2023) study found no significant difference in academic performance between concrete and virtual manipulatives. Nonetheless, the virtual manipulatives were preferred by all three participants as the hint signaling empowered them to be more independent. Bone et al.'s (2023) study is especially insightful as the participants were diagnosed with cognitive processing deficits in the areas of information retrieval and attention regulation. According to Asim et al. (2020), middle school ages are at high risk for disengaging from learning. Liu et al. (2022) recommended gamification and simulations due to their high levels of manipulatives. Although, Gouseti (2021) warned against arbitrary implementation of play-based learning as independent eLearning is difficult for younger grades.

Social signals can promote effective cognitive management when used as a scaffolding tool (Fiorella, 2022; Pilegard & Fiorella, 2021). Structural gestures are a type of social signal in which an instructor facilitates mental organization through the use of intentional hand motions (Pilegard & Fiorella, 2021). Intentional pointing can result in better academic performance, reduce visual searching, and strengthen cognitive engagement (Pi et al., 2019). Purposeful gesturing or other high-embodied motions can increase knowledge transfer; although, the impact on retention is uncertain (Doherty, 2022). Conversely, gaze guidance can lead to an increase in transfer and retention (Pi et al., 2020). Likewise, emotional facial expressions can enhance retention (Pi et al., 2021).

While CLT and CTML assume active engagement, working memory is maximized efficiently when learners are doing the task or activity themselves (Cojean & Jamet, 2021; Knoster & Goodboy, 2023; Novak & Schwan, 2021). Eitel et al. (2020) warned that students must be able and willing to control their cognitive processing in order for learning to be

effective. Fisher et al. (2014) corroborated by stating that focused attention is a requirement of active learning. Motivational cues can promote working memory balance; otherwise, if the task if the task difficulty is too high, the learner may experience cognitive disengagement (Paas & van Merriënboer, 2020).

Motivation is an essential component of CTML because active learning requirements high involvement (Skulmowski & Xu, 2022). Cognitive capacity can be quickly depleted if motivation is not present, tasks are assigned rather than chosen, or tasks are too complex (Xu et al., 2021; Zhang & Lin, 2020). In Baten et al.'s (2020) study, they found that if students perceived that the task would be too difficult, then their motivation and focus would diminish. Alternatively, mental processing capabilities can be expanded through growth mindset practice (Dweck, 2017; Skulmowski & Xu, 2022). Students with growth mindsets reported lower intrinsic and extraneous cognitive loads (Xu et al., 2021).

Since working memory is the active learning center, signaling can optimize usage through regulating or organizing the new information (Anmarkrud et al., 2019; Bolkan & Goodboy, 2020; Carter et al., 2020). Regulation can be in the form of managing modality or channel processing (Krieglstein et al., 2022b). Organization ameliorates the generative process (Fiorella et al., 2020). Through the use of graphic organizers or scaffolding designs, educators can optimize cognitive engagement because mental capacity is already constructed in an efficient manner (Bacca-Acosta et al., 2022; Bolkan & Goodboy, 2020).

Preventing Cognitive Overload

In virtual education, the entirety of the learning processes is dominantly on the learner which puts the emphasis; therefore, the other forms of engagement should be considered to prevent cognitive disengagement or overload (Zhong & Lyu, 2022). Affective (emotions),

behavioral, and social engagement can influence cognitive performance (Seymour et al., 2020; Sweller et al., 2019; Xiao et al., 2020; Zhong & Lyu, 2022). Recently, Zhong and Lyu's (2022) study added agentic engagement in which students are proactive defining what they want and need from learning; although, this category was not highly accentuated. Either way, engagement is multidimensional in which the components influence one another (Wang et al., 2019a).

Affective engagement involves how a student feels during the activity (Zhong & Lyu, 2022). Henrie et al. (2018) distinguished cognitive engagement as a student's effort to learn while emotional engagement indicates a willingness to learn. Emotions significantly influence mental processing. For example, if students feel inadequate at a given task, their cognitive capacity is consumed by the fear of failure (Baten et al., 2020). These affective issues such as feelings of cynicism and low self-esteem can lead to cognitive disengagement- especially with virtual students who may lack communal support (Thuruthel & Tungol, 2021). Furthermore, parents often opt into sending students to a virtual school for emotional safety to escape bullying; thus, online students may already be vulnerable (Carter et al., 2020). According to Magana et al. (2022), confusion, frustration, and boredom are emotions that can directly lead to cognitive disengagement. Zhong and Lyu (2022) made the argument that emotional engagement should have the highest consideration.

In distinction from how students feel or think, behavioral engagement explains how they act (Kew & Tasir, 2021). Eden et al.'s (2022) study emphasized how the behavioral component cannot be analyzed independently from emotional and cognitive engagement. Moreover, behavioral engagement tends to be the most researched as active participation is easier to observe than the other categories (Bergdahl et al., 2020; Kew & Tasir, 2021). Although, cognitive and emotional engagement usually predate behavioral engagement (Henrie et al., 2018). For virtual

students, behavioral disengagement is in the form of absenteeism and dropout (Piscitello et al., 2022).

As Beck et al. (2022) defined behavioral engagement as the physical energy required to complete a learning task, exhaustion can expedite cognitive overload. In addition, biological stressors (such as increased heartrate and perspiration) can interrupt student focus and working memory function (Jopling et al., 2021). Therefore, physiological data can be used to track changes in cognitive load for prevention (Larmuseau et al., 2020). Educators can either lower challenge expectations or provide more scaffolding for the activity if students are experiencing fatigue or heightened stress (Baten et al., 2020). Also, embodiment signaling can increase the effectiveness of behavioral and cognitive engagement as students are learning kinesthetically (Doherty, 2022). This happens because dynamic drawings create temporal continuity through signaling (Fiorella et al., 2020).

Social engagement is particularly important for middle school students because they are developing their interpersonal skills (Asim et al., 2020). Learning across a device in virtual education is an added challenge to promote social engagement (Rincón et al., 2021). Although, Bağriacik and Karataş (2022) found that students who dropped out were more impacted by environmental factors than social integration. The global COVID-19 pandemic increased the disparity of social interactions which led to lower cognitive engagement (Carter et al., 2020; Gouseti, 2021; Knoster & Goodboy, 2023). Even established virtual school families required additional emotional and social support during the pandemic (Carter et al., 2020).

Cognitive overload can be reached quicker when other health impacts are perpetuated by social disengagement (Seymour et al., 2020). On the one hand, students could feel a social pressure to be online. Bergdahl et al. (2020) explained that in some cases social pressures led

students to feelings of exhaustion or inadequacy thus depleting cognitive processing. On the other hand, social pleasing can result in controlled motivation that leads to increased engagement (Zhang & Lin, 2020).

For virtual learners, social engagement means a preference of technology mediated participation in communication with teachers and peers (Bergdahl et al., 2020). Cojean and Jamet (2021) defined social engagement as participating with social platforms or interacting the digital environment. Wang et al. (2019a) expanded their definition to include observable and unobservable participation with school activities. Discussion forms are an effective social platform in which students can learn valuable social knowledge construction through virtual interactions (Kew & Tasir, 2021).

Multimedia has become pivotal for the contemporary social structure of online teaching (Guo et al., 2020). According to social agency theory, when students feel connected with the instructor, they will actively engage their working memory (Fiorella et al., 2020). Even animated characters can induce less cognitive load if they are utilizing proper social signaling (Li et al., 2022). Eye contact can increase memory for spoken words; whereas, direct gaze may consume cognitive capacity and lead to decreased retention and encoding (Lanthier et al., 2019). Furthermore, facial expressions could cause split attention because students may dwell on the emotions shown in the instructor's face rather than the information (Pi et al., 2021). Direct gaze can also break cognitive processing faster as students mentally multi-task between what is being said and seen (Rato et al., 2019).

Split attention is a detriment to cognitive engagement as learners are required to keep significant amounts of information in their working memory simultaneously (Moon et al., 2022). When information is non-integrated, cognitive overload is a possibility due to decreased stamina

for the given learning task (Moon et al., 2022). Consequently, working memory capacity can be expanded for elaboration if the learner embeds the mental activity in the environment known as "cognitive offloading" (Novak & Schwan, 2021, p. 643). Technology can either adversely or positively influence cognitive load (Beck et al., 2022). For instance, searching websites for information or toggling between multiple browser tabs can lead to cognitive disengagement; however, using two monitors can prevent cognitive overload (Miller et al., 2020).

Educators can enhance learning through the creation of intentional structures. Students will be more engaged if they are familiar with the technology or program being used (Zhong & Lyu, 2022). Content learning can be challenging, let alone adding the need for digital literacy skills (Roblyer & Marshall, 2002). For instance, the complexity of educational platform navigations can either be processed as ICL or ECL (Bahari, 2022). If students are familiar with the educational platform, they will be able to focus on the content; otherwise, students' ECL will increase due to the necessary expenditure of energy in simultaneously processing the online learning system as well as the content (Henrie et al., 2018). Skulmowski and Rey (2020) explained that learning performance will continue to increase until the scenario becomes too complex. Cognitive load theory (CLT) warns of overload if the complexity of the task exceeds the capacity of working memory, which would inhibit learning (Andersen & Makransky, 2020).

As educational technology continues to evolve, so to should educators understanding and implementation of it (Rodemer et al., 2022). Gamification is a current educational trend as engagement is increases through the use of exciting graphics, puzzles, and rewards (Qiao et al., 2022). Mayer et al. (2020) warned that the purpose of multimedia learning should be to teach rather than to entertain. Gamification works due to immersive illustrations, immediate feedback, and reinforcement of desired behavior; however, the technology can be expensive, inequitable to

access, and instructors may lack the digital skills required for proper operation (Qiao et al., 2022). Simulations (such as augmented and immersive virtual reality) have been implemented in high-risk fields like medicine and aviation (Andersen & Makransky, 2020). Students are able to practice required technical skills in a safe environment (Chang et al., 2020; Liu et al., 2022). Likewise, virtual reality field trips have become popular in both brick-and-mortar and virtual learning because they provide opportunities for students to explore distant locations (Makransky & Mayer, 2022).

Complex technologies are more susceptible to promoting cognitive overload (Bacca-Acosta et al., 2022). Simulations are an immersive experience in which multisensory channels are engaged concurrently (Albus et al., 2021). Low immersion has limited interactivity with a single monitor, mouse, or keyboard while high immersion can use more sophisticated technology such as head mount displays and headphones (Liberman & Dubovi, 2023). Virtual reality is more complex than multimedia videos because it strives to mimic the real world through integrating haptics or touch (Liberman & Dubovi, 2023; Mayer et al., 2020; Webb et al., 2022). While research into haptic use is new, signaling with touch have not shown significant gains in learning (Webb et al., 2022).

Simulations tend to elicit a lot of extraneous cognitive load; therefore, instructional designers need to be intentional about virtual reality's use (Liberman & Dubovi, 2023). As digital environments are visually rich, students reach cognitive capacity quickly (Fiorella et al., 2020; Fisher et al., 2014). Proper scaffolding with organizational signals can lead to spatial contiguity and prevent cognitive disengagement (Bacca-Acosta et al., 2022). Adding virtual labs can be a cost-effective way to help students understand real world phenomena, but teachers need to designate specific learning tasks to guide learner focus (Liu et al., 2022). The manipulatives in

online programs contain signaling cues that streamline mental processing, so students can not only maintain a reasonable cognitive load but also feel success and ownership of their learning (Bone et al., 2023).

The type of signaling used is also an imperative component for educators to consider (Knoster & Goodboy, 2023; Liu et al., 2022). Cues can prevent cognitive overload if they draw learners' attention quickly and efficiently (Ring et al., 2021). Unfortunately, there is no prescribed method (Mayer, 2017). According to Moon and Ryu (2021), information processing behavior changes with visual information. People tend to focus their attention longer on text rather than pictures unless the pictures are realistic with high definition and details (Moon & Ryu, 2021; Skulmowski & Rey, 2020). Similarly, a higher cognitive load is produced when learners look at an animation for a shorter length of time (Zu et al., 2020). Summarizing or concrete examples can also be forms of signaling which may not help with transfer but retention of information (Bolkan & Goodboy, 2020).

For signaling to be effective, it needs to be implemented in a meaningful and appropriate way. When students have the skills to deal with complex instruction, cueing should not be integrated (Eitel et al., 2020). Misuse of signaling can lead to a reduction in learning through the exacerbation of ECL (Bahari, 2022). On the one hand, learners can become overwhelmed if visual or textual cues are overused in frequency or variety (Alpizar et al., 2020). According to Ring et al. (2021), learners can become complacent if signaling is consistently utilized in a structured manner. This "passive-receptive" learning prevents engagement into deeper processing (Ring et al., 2021, p. 44).

Another detriment to the learning process are errors in long-term memory storage. Magana et al. (2022) explained that students will experience "cognitive disequilibrium" if the

new information being learned contradicts their prior knowledge (p. 877). Misconceptions deplete mental performance rapidly because the student has to unlearn the incorrect information and build a corrective schema (Rodemer et al., 2022). Dismantling misconceptions can become extensively difficult if the misinformation has already been organized into an automized schema (Magana et al., 2022). According to Novak and Schwan (2021), a potential solution would be for educators to teach students how to simplify mental routines thus causing a decrease in cognitive load and minimizing errors.

Summary

A benchmark of successful education is student engagement- regardless of the platform (Agustini et al., 2022; Alpizar et al., 2020; Altmeyer et al., 2020; Andersen & Makransky, 2020; Bergdahl et al., 2020; Carter et al., 2020; Kew & Tasir, 2021). Despite virtual education's history, global attention to online learning did not occur until after the COVID-19 pandemic; however, e-learning and distance learning are very different types of asynchronous learning (Bağriacik & Karataş, 2022). Regardless of the asynchronous practice, virtual students are substantially less likely to graduate compared to their in-person counterparts (Xiao et al., 2020). Impacts of student engagement as well as preventative solutions to disengagement have been widely researched for both virtual and in-person education (Beck et al., 2022; Bergdahl et al., 2020; Daily et al., 2020; Huh et al., 2019). Among the influential types of engagement, cognitive overload is particularly determinantal to the online student due to its propensity to segregate the learner from the educational environment altogether (Agustini et al., 2022). To combat cognitive disengagement, cognitive load theory and the cognitive theory of multimedia learning provide guidance for educators to reduce extraneous cognitive load through signaling (Bahari, 2022; Beege et al., 2021). While the effectiveness of signaling has been well-researched, there is a gap

in the literature regarding which signaling methods are best to combat cognitive overload (Alpizar et al., 2020). Furthermore, the perspective of virtual middle school students during cognitive disengagement and signaling are also absent (Moon et al., 2022).

CHAPTER THREE: METHODS

Overview

The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students during cognitive disengagement and the use of signaling in the virtual learning setting. At this stage in the research, signaling is defined as visual or auditory cues that direct learner attention to critical information (Clark & Mayer, 2016; Mayer, 2017). This chapter provides a comprehensive overview of the research design along with replicable study details: research questions, setting, participants, this researcher's positionality and role, procedures, data collection, and data synthesis. This chapter concludes with reverential discussions regarding trustworthiness and ethical considerations for this investigation.

Research Design

This transcendental phenomenological qualitative study focused on understanding the lived experiences of virtual middle school students and their response to the use of signaling. Cognitive architecture, multimedia learning, and signaling research have been dominated by quantitative studies; therefore, this qualitative study was appropriate because the perspectives of human experience have been absent (Doherty, 2022; Klepsch & Seufert, 2020; Mayer, 1999, 2014, 2017; Moustakas, 1994). In particular, qualitative research provided a thorough and holistic analysis of the given phenomenon (Moustakas, 1994). The qualitative methodology was ideal for this investigation as the aim was to better understand the influence of the cognitive overload phenomena, its relationship with disengagement, and subsequent resolution through signaling (Albus et al., 2021; Alpizar et al., 2020; Bahari, 2022; Creswell & Poth, 2018). Qualitative research provided an effective progression by establishing the theoretical framework

and then identifying philosophical assumptions through an interpretive lens in order to analyze the phenomena (Creswell & Poth, 2018; Moustakas, 1994).

The selection of a transcendental phenomenological approach was intentional as this methodology not only provided a solid systematic design but also emphasized the internal emotions and metacognitions of the learners (Moustakas, 1994). These characteristics were particularly critical for this study in order to differentiate disengagement due to cognitive overload rather than the other highly researched categories of behavioral, emotional, and social impacts (Bergdahl et al., 2020; Wang et al., 2019a). Furthermore, this study's middle school student participants will have shared the signaling learning experience (Creswell & Poth, 2018).

Based on the work of Husserl, phenomenology is unique from other types of qualitative studies because of the thorough and complete analysis of a particular experience (Moustakas, 1994). In other words, researchers develop a fully comprehensive portrayal of a given event by utilizing a structured reflective analysis process which can be divided into four main stages: epoché, phenomenological reduction, imaginative variation, and synthesis (Moustakas, 1994).

Because the researcher was the human instrument in qualitative research, he or she must first undergo bracketing during the epoché stage (Moustakas, 1994). Bracketing is the compartmentalization of the world event by acknowledging and segregating one's own biases or prejudices (Moustakas, 1994). Separative journaling ensures that the data was analyzed through a fresh perspective each time (Liao et al., 2021). Bracketing was integrated throughout the data collection and analysis phases because that was an essential primary step.

Next, the phenomenological reduction stage involved capturing observations of the completed lived experiences of the participants through the phenomenon (Creswell & Poth, 2018). Moustakas (1994) highlighted that this process includes both internal and external

observations. While this stage begins the development of themes, the objective is to truly understand the phenomenon itself and its influential connection to the participant (Liao et al., 2021; Moustakas, 1994).

The third stage is properly named: imaginative variation. During this step, the researcher began to develop connections, themes, and experiential causations which was only limited by his or her imagination (Moustakas, 1994). The focal is often defining the "how" for the phenomenon (Liao et al., 2021, p. 14; Moustakas, 1994, p. 94). As the researcher utilized multiple perspectives to analyze the phenomenon, structured explanations became increasingly solidified (Moustakas, 1994).

Finally, the synthesis stage polished the results for presenting. The combination of "textural and structural descriptions" leads to one coherent "essence" as coined by Husserl (Moustakas, 1994, p. 100). After analyzing all components from every possible angle, the researcher as the human instrument was able to describe the phenomenon in its entirety (Liao et al., 2021). Overall, this phenomenological process is significant because the structure not only promoted integrity throughout the analysis but also enhanced the researcher's expertise (Moustakas, 1994).

The phenomenological design by Moustakas (1994) of this qualitative study was ideal due to the overwhelming need to provide a holistic analysis and to fulfill the purpose of my research. The investigation aimed to understand the lived experiences of virtual middle school students during cognitive disengagement and their response to the use of signaling. Virtual learning utilizes a lot of multimedia, and signaling is among the best practice strategies because it directs learners' attention to the most relevant information (Arslan-Ari & Ari, 2021; Mayer, 2017). Moreover, the qualitative insight was missing from the research (Klepsch & Seufert,

2020). Additionally, this was a transcendental study because I do not share the lived experience with the participants (Creswell & Poth, 2018). Furthermore, the nature of this investigation required an in-depth perspective that could be scrutinized from multiple vantage points (Moustakas, 1994).

Research Questions

The purpose of this transcendental phenomenological qualitative study was to understand the lived experiences of virtual middle school students during cognitive disengagement and their response to signaling. The purpose was achieved through the theoretical framework. The theory of multimedia learning (CTML) is an inseparable companion to cognitive load theory (CLT) for learning because these theories explain how instructional design can promote cognitive engagement in online learning (Alpizar et al., 2020; Mayer et al., 2020; Sweller, 2020). For example, signaling has been extensively verified in optimizing working memory because cues direct learner attention; thus, cognitive architecture is balanced and not to exceed mental capacity (Albus et al., 2021; Almasseri & AlHojailan, 2019; Mayer, 2017). However, there was a gap in the literature with regards to understanding the cause of cognitive disengagement and the preventative capacity of signaling in virtual learning (Alpizar et al., 2020; Jopling et al., 2021). Therefore, the research questions for this study were as follows:

Central Research Question

What are the lived experiences of virtual middle school students during cognitive disengagement and signaling?

Sub-Question One

What are the perceived causes of cognitive disengagement in virtual middle school students?

Sub-Question Two

How do middle school students describe the influence of signaling on cognitive disengagement in virtual learning?

Sub-Question Three

What type of signaling (if any) is perceived by middle school students as most effective in virtual learning?

Setting and Participants

Virtual schools have been on the rise in recent decades, and as of 2012, all 50 of the United States offer some form of K-12 online learning (Waddell, 2017). By 2016, there were over one million students enrolled in a virtual K-12 American school (Zhang & Lin, 2020). After the COVID-19 global pandemic, virtual education expanded in a multifaceted way (Beck et al., 2022). The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. Signaling is an integral counterpart to online education because signals (or cues) can be utilized in either the visual or auditory forms of multimedia; signals direct learners' attention to critical information (Clark & Mayer, 2016; Mayer, 1996, 2017; Mayer et al., 1999). The site and participants were selected accordingly to fulfill the purpose, and pseudonyms were used throughout this study for identity protection.

Site

The site for this study was online as participants were recruited from a virtual school (Rigel) in an upper Midwest American state. This nationally accredited and recognized virtual school is governed by an international private organization (Orion) and operates for profit. While some of the sister virtual schools in this state are associated with a particular school district,

Rigel is a singular site, categorized as a charter school in association with the state's transitional charter school district. The office of this site is located in the state's capital city; however, students are located all across the state and employees all across the nation.

This particular virtual school site was selected for multiple reasons. I am currently employed at this institution and was granted preliminary support to proceed with this research once sanctioned with IRB approval. Additionally, the parent company (Orion) allows for some autonomy among virtual schools as orchestrated by the school's leadership team. For this reason, only this one site (Rigel) was selected to ensure consistency of what students were experiencing. Causes of disengagement can be more easily scrutinized if the course structure, pedagogy, and academic supports are uniform (Barbour, 2022). Furthermore, the parent company (Orion) defines this site (Rigel) as between a small and medium sized institution as it serves a population of about 4,000 students. In comparison, a large size is defined as serving around 10,000 students. According to Waddell (2017), smaller virtual schools demonstrate greater student achievement than their larger sized companions.

Participants

This site was also selected due to the diversity of the potential participants. Four main types of engagement can influence student learning: affective (or emotional), behavioral, cognitive, and social (Beck et al., 2022; Piscitello et al., 2022; Wang et al., 2019a). In order to focus on cognitive, the other variables need to be streamlined. While Rigel has below the state's overall racial minority average, the racial diversity within the middle school grades is higher. Specifically, this study aimed to recruit seventh and eighth grade students as I was currently teaching sixth grade. There was the possibility that the volunteer participants would have been former students of mine. On the one hand, the student-teacher connection strengthens social

engagement (Piscitello et al., 2022; Wang et al., 2019a). In addition, there was no unethical risk for academic conflict. The bracketing process provided further eradication (Moustakas, 1994).

Students residing in middle school (ages 11-14 years old) were selected due to the gap in signaling and multimedia research (Bolkan & Goodboy, 2020). Typically, students in high school or at the collegiate level have been recruited. Bone et al. (2023) identified that more information is needed on how technology can help this particular age group learn. Middle school students are at greater risk for academic failure due to losing focus and cognitively disengaging (Asim et al., 2020). Likewise, younger students have higher autonomous motivation or drive for engagement, and middle school students are highly capable of articulating their experiences (Webb et al., 2022; Zhang & Lin, 2020).

As a transcendental phenomenological qualitative study, the sample size of 15 middle school students was employed. This allowed for the potential of withdrawals while maintaining the minimum requirement of 10 participants. While gender was not explicitly sought, Zu et al. (2020) acknowledged a gender imbalance due to convenience sampling; female participants tend to dominate the research, so I strove to be balanced (Fiorella, 2022; Novak & Schwan, 2021). In addition, the potential participants had a shared the lived experience of the signaling phenomenon (Creswell & Poth, 2018).

Recruitment Plan

The targeted volunteer participant sample group was middle school students (ages 11-14 years old) at this one Midwest virtual school site (called pseudonym Rigel). Utilizing one site was important in order to focus in on cognitive disengagement as the phenomenon and ensure that the potential participants would have a shared lived experience of the signaling phenomenon (Beck et al., 2022; Creswell & Poth, 2018). Criterion sampling was used because volunteer

participants needed to self-identify as intrinsically motivated. If participants are not internally motivated, then their cognitive disengagement may be skewed due to behavioral choices instead of cognitive overload (Bergdahl et al., 2020; Sweller, 1988, 2011).

Participants were recruited via WebMail once approval from both Liberty's IRB and the site (Rigel) were attained. The approved recruitment letters were sent to students in 7th and 8th grade (see Appendix C) as well as their parents and guardians (see Appendix D). At that time, there were approximately 300 students in 7th grade and 350 students in 8th grade at Rigel virtual school. Thirty-eight families responded to the recruitment WebMails. Six families did not schedule the screener phonecall. There were 25 students that were eligible to participate in this study. A second round of scrutiny was performed by reviewing what and how the potential participants answered the screener questions. Likewise, diversity of perspectives was taken into consideration. This study involved 15 participants: five 8th grade participants (one male and four females) and ten 7th grade participants (six males and four females).

Researcher Positionality

As a scientist who strives for objective research, Creswell and Poth (2018) would define me as a postpositivist because my logic is based on extensive prior research. My particular area of interest is in multimedia learning which is validated through this learner-centered model focused on working memory through the reduction of cognitive effort (Clark & Mayer, 2016; Sweller, 2020). Additionally, inquiry-based explorations are intriguing due to their cognitivism exploration which is grounded in thought and learned through a processing model (Schunk, 2016). This interpretive framework has a systematic approach that investigates multiple experiences followed by a multifaceted analysis of the data (Creswell & Poth, 2018). When conducting research, I followed this paradigm to ensure comprehensive synopsis. I planned to

conduct my research in multimedia learning through a phenomenological qualitative approach as the postpositive framework was predisposed to this methodology.

Interpretive Framework

The positivist paradigm has received criticism due to a lack of concrete fundamentals (Creswell & Poth, 2018); however, as a Christian postpositivist, there are many absolutes established in God's Word that I believe in. Jesus was sent by God to be the Savoir who redeemed our world by becoming our sin so that we may enjoy our lives (John 3:16; Luke 19:10; 1 John 4:14; John 10:10, NIV, 2020). Likewise, the Holy Spirit was sent to guide us in emulating Christ's mindset through developing the fruits of the spirit (John 15:26; Romans 8:6; Philippians 2:5; Galatians 5:22-23, NIV, 2020). Furthermore, God eternally partners with His believers and empowers them to serve others while bearing witness (Deuteronomy 31:8; Joshua 1:5; Isaiah 41:10; Acts 20:35; Luke 6:31; Philippians 4:13; Matthew 28:16-20, NIV, 2020). As a Christian, my research was grounded in these absolutes. Phenomenological qualitative research is heavily dependent on people's stories and experiences (Moustakas, 1994). It was my responsibility to treat each interaction with integrity and strive for objectivity. These promises have been comprehensively scaffolded in this Chapter Three's data collection and trustworthiness discussions demonstrating their implementation.

Philosophical Assumptions

Qualitative research methodologies are influenced by the researcher's ontological, epistemological, and axiological assumptions; therefore, it is important for a researcher to be cognizant of her or his own foundations prior to conducting investigations. In this section, I explicitly bracketed my assumptions. The ontological assumption section will explain my beliefs and perception of nature's reality. The epistemological assumption section explains how I

addressed the subjectivity of this qualitative investigation. Then, the axiological assumption section outlined the background of my values that could have influenced my perceptions during data analysis.

Ontological Assumption

Ontology is the study of one's reality and existence (Bibi et al., 2022; Creswell & Poth, 2018). My ontology is rooted in my identities as a Christian, scientist, and postpositivist. As a postpositivist, I tend to synthesize a monotheistic understanding based on the biblical truths or absolutes established in Jesus and the Holy Spirit. My ontological assumptions are grounded in the other part of the holy trinity: God the Father. God created the natural world and humanity to take care of all living things (Genesis 1:1-31, NIV, 2020). As a Christian scientist, my understanding of reality has been built on my interactions with all that God has created. Although, the perceptions of my five senses created an individualized experience that was different from others; therefore, it was my duty as a researcher to ensure that I asked clarifying questions to gain a full and well-rounded understanding of the interviewees' experiences.

Epistemological Assumption

Epistemology examines how knowledge of reality is perceived, measured, and communicated to others (Bibi et al., 2022). In alignment with my ontological assumptions, my epistemological views have the same biblical foundation. Paul expressed that we are called to be like-minded as Jesus (Philippians 2:5, NIV, 2020). Additionally, effective qualitative research occurs when the researcher emulates participant experience as closely as possible (Creswell & Poth, 2018). God emulated the human experience when Jesus was sent to live on earth to increase His empathy of our experience (1 Timothy 3:16; NIV, 2020). Moreover, Creswell and Poth (2018) emphasized the importance of maintaining objectivity. Jesus was intentional about

being objective (Matthew 7:1, NIV, 2020). I strived to achieve this as a Christian, scientific researcher to ensure that I was analyzing participant data within the context of their perceived reality. My epistemological assumption was knowing a well-rounded view of an interviewee's experience.

Axiological Assumption

Axiology captures the core values of the researcher as outlined by societal and cultural characteristics (Antoniuk et al., 2022). I agree with Creswell and Poth (2018) that a researcher's biases should be kept out of the data; however, in order to accomplish this, one needs to firmly identify her or his implicit biases. My foundational identities (as established in my ontology and epistemology assumptions) accompany my background with regards to my axiological assumptions. I was born in a third world country, and adopted as a toddler by two Christian, White Americans. My adopted family is Ukrainian, German, and Norwegian. After growing up in a suburban middle-class environment, I supported myself through college by working three jobs. Since then, I rarely have held less than two occupations. It did not take long after joining the work force for me to segregate politically from my Midwest roots whom voted solely based on pressures of family tradition and short sights without the due diligence of research. Based on my life experience, my axiology is grounded on the moral values of integrity, honesty, servant leadership as well as hard work. I do not respect those who are intolerant of opposing views, do not earn what they have, and live hypocritically. Having taught across this great nation from Title I to private schools, the educational realm has proven to be a hostile environment for someone with my axiology (John 15:19-20; 2 Timothy 3:11-12, NIV, 2020). Despite working in a secular school district, I have strived to instill the biblically rooted values in my students that our public education system was founded on (Peterson, 2010; Smith, 2020). This has been

accomplished through leveraging an inquiry-based teaching method and intentionally using verbs such as *earning* grades rather than *getting* them. I continued to be conscious of my axiology and strived to prevent judgement during data analysis by thoroughly interviewing to capture and acknowledge each participants' full situation.

Researcher's Role

As the human instrument, I personally conducted all three collection methods and analyzed the data in multiple stages. There was the possibility of participants having been former students of mine as Rigel virtual school is my current place of employment; however, volunteer participants were recruited in grades that I do not teach. I did not have any authority over the participants. If they were former students of mine, there was an added benefit of already having that established trust (Creswell & Poth, 2018). In an attempt to bracket biases and prejudgments, I engaged in extensive journaling throughout the data collection process. that journaling was audited by the Dissertation Chair and Methodologist (who mentored me) as well as myself. As a virtual middle school science teacher and fourteen-year educator, I was open to the experiences of signaling and multimedia learning being unique to each student. I anticipated that saturation of causes for cognitive disengagement were fulfilled within the triangulation of the three methodologies. Having spent the majority of my educational career working with middle school students, I anticipated their clear ability to verbalize their experiences; however, abstract self-interpretation may be difficult in a few instances (Barney & Leavitt, 2022; Semeraro et al., 2020).

Procedures

There are multiple milestones in order to successfully replicate the procedure for this investigation into the lived experiences of virtual middle school students during cognitive

disengagement and signaling. The first stage was securing Liberty's Institutional Review Board (IRB) approval along with the site's permissions to conduct the research. Extensive paperwork that outlined a comprehensive explanation of the research and ethical considerations as well as module completion was required to earn IRB approval. Once IRB approval was earned, this verification was sent via email to the respective leaders of the site for their permission. In an August 2022 email, both Orion and Rigel site leaders provided preliminary verification stating that they would comply with the research that receives Liberty's IRB approval. In order to gain site approval, an IssueAware (IA) was created outlining the full scope and sequence. This will automatically generate an email notification to all stakeholders. See Appendix A for Liberty's IRB approval and Appendix B for Orion and Rigel's approval.

Once research conduction was sanctioned, I recruited volunteer participants from the Midwest virtual school site via WebMail (their secure email server). See Appendices C and D for IRB approved recruitment materials. As participants were middle school students (ages 11-14 years old), both parent consent and student assent were obtained. See Appendix F for the student assent form, and see Appendix G for the parent consent form. When a student or parent responded to the WebMail recruitment, a phone conference with all parties was scheduled along with the written overview and contract that were preapproved by Liberty's IRB. During the phone call, parents and students had the opportunity to ask questions and verbally confirmed that they fully understood both the volunteer nature of participation in addition to expectations of the study. The participant screening phone call and questions can be found in Appendix E. Parents and students needed to WebMail written permission prior to meeting.

Individual interviews, questionnaires, and focus groups were the three data collection methods, respectively. After written permission was obtained by both parent and student,

individual interviews were scheduled first. The student met me via Zoom Class (LiveLesson) for an hour. I thoroughly journaled and bracketed my headspace (thoughts, feelings, conceptions, anticipations, concerns, etc.) prior to the individual interview. The student agreed (from the permission) to be on webcam and use the microphone. A chat pod was also available if needed. The meeting was recorded, and the interview was conducted as a discussion. Immediately after the interview, I verbally dictated into a secure Microsoft One Note program a reflection of that interview.

After each interview, a thank you WebMail was sent to the student participant. The gratitude WebMail contained a verbatim transcript of our interview for them to verify. Participants were given a week to verify this transcript. A call or text was also sent to the parent and student as a reminder that a transcript has been sent and required attention. Once verified, a response WebMail was sent with a link to the secondary data collection method (the questionnaire). As the questionnaire was in Google Forms, participants were able to send an email copy immediately to their personal account. Participants had two weeks to complete the questionnaire. Again, a call or text to both parents and students was used as a follow-up communication for the WebMail. Once the first cycle of analysis was complete, I sent a WebMail to the participant with a link to their initial responses and the first cycle of coding for their review. Participants had the opportunity to verify or make changes to their responses.

After all individual interviews were conducted, focus groups were formed. Students were assigned to focus groups based on their grade level (seventh or eighth grade). The goal was to have three focus groups with five participants in each group because the total number recruited will aim for 15 participants. Students were given three meeting time choices. Their selection mediated a random grouping. On the day of the focus group, a call or text reminder was sent to

each parent and student. Again, I journaled prior to the meeting to bracket my biases. Focus groups were held in Zoom Class (LiveLesson). I reviewed expectations and norms (as outlined below in the first question). Participants used their webcams and microphones similar to the individual interviews. Each focus group was schedule for a one-hour duration but with no limiting time constraint. Immediately after the focus group, I verbally dictated reactions and journal into the secure One Note for audit during the analysis. All participants received a copy of the verbatim transcript for their approval after the meeting. Each participant had a week to confirm accuracy of or make amendments to their statements. Participants were coded with pseudonyms for confidentiality within the research data.

Triangulation successfully occurred once the same volunteer participant has completed all three tasks: individual interview, questionnaire, and focus group. This led into the second cycle of coding at which time participants received the secondary analysis results for verification or correction. Triangulation was confirmed once each participant validated the triad of statements. Saturation was obtained once consistent themes emerge from the second cycle of coding with more than half of the participants.

Data Collection Plan

The purpose of my transcendental phenomenological qualitative study was to understand the lived experiences of virtual middle school students during disengagement and signaling and multimedia learning. In order to fulfill this purpose, three data collection methods were employed. Triangulation can be understood as a best practice for phenomenological qualitative research due to the comprehensive collection of various perspectives (Farquhar et al., 2020). Individualized interviews, questionnaires, and focus groups were the three data collection methods, respectively. These methods allowed for open-ended and semi-structured interactions

that captured well-rounded experiences (Moustakas, 1994). Analysis of these data collection methods followed Moustakas's (1994) modified version in alignment with Saldaña's (2021) process of coding. Preliminary analysis occurred for each method before compounding the first data cycle with the following collection method set (Saldaña, 2021). Then, triangulation was synthesized in the second cycle once all data had been collected (Farquhar et al., 2020; Moustakas, 1994; Saldaña, 2021).

Individual Interviews Data Collection Approach

The initial interviews were critical to building trust (Creswell & Poth, 2018). Keeping the audience in mind, the questions were written in a simplistic form to explain the purpose of the investigation and to connect with the middle school participants (Bean, 2014; Kalemkuş & Bulut-Özek, 2022). The hour-long individual interviews took place in Zoom Class (LiveLesson). This digital platform was selected because Rigel virtual school students are comfortable and skilled with using that platform. According to Bahari (2022), unfamiliarity with digital platforms can negatively impact the learning experience. During the interview, the questions were displayed while video and audio were recorded. Both the participant and the researcher were on their webcam and used the mic to build a social connection as well as for the analysis of the nonverbal cues (Pi et al., 2021). The recordings were housed within the site's two-step verification secure server. The site school name has been replaced by its pseudonym (Rigel) to maintain confidentiality. These questions have also been stored in Appendix H.

Table 1

Individual Interview Questions

1. Greetings, Scholar! Thank you for speaking with me today. We will be discussing how you learn. There are no right or wrong answers because this is about your

experience, so please feel empowered to be honest. Plus, remember that your responses are all confidential meaning that I will not be telling anyone else (like your current teachers or Learning Coaches) about what you share. This is a safe space. I am excited to learn about your story. Let us start with your background. Please tell me about you and about your family.

2. What are some hobbies or activities that you enjoy doing?
    a. Clarifying question: What is your favorite, and why?
3. Let us shift to discussing your school experience. Please tell me about your journey at [Rigel] thus far.
    a. Follow-up question: How long have you been at Rigel?
    b. Follow-up question: What other types of schooling did you do before Rigel?
    c. Follow-up question: What will your future schooling be like?
4. How do you feel about being a virtual student and learning online? CRQ
    a. Follow-up question: What is your favorite and least favorite class? CRQ
    b. Follow-up question: Describe your typical school day or routine. CRQ
5. Next, I have a two-part question. First, I want you to think about a time when you were really excited or loved a lesson. Describe that day and how it made you feel. SQ1
6. How do you know what information is important in a lesson? SQ2
    a. Follow-up question: Please give me an example of when a teacher helped you identify the important information? SQ3
    b. Follow-up question: Tell me about a time when your Learning Coach helped you complete a lesson. SQ3

7. Second part, I want you to think about a time when learning was complex. Describe that day and how it made you feel. SQ2
8. *Collins Dictionary* (2024) defines disengagement as separating or detaching from something. In your experience, what does disengagement look like, sound like, feel like? CRQ
    a. Follow-up question: what is happening in your mind during disengagement? SQ1
9. Let us go back to thinking about your hobby (from question 2). We know that there are a lot of reasons for having to stop (weather, time, parent says so), but think about a time when it was totally up to you to stop. Explain what happened or why you decided to do something else. SQ1
10. Similarly, there are many reasons to disrupt a school lesson. We are going to focus though on our thinking, specifically. Please give me an example of a lesson when you spaced out or found yourself no longer paying attention? SQ1
    a. Follow-up question: What situations make it challenging to focus? SQ1
    b. Clarifying question: lesson structure or layout SQ1
11. Thank you so much for sharing your experience. I have one more question that will preview the next research steps of the questionnaire and the focus group. In your experience, how do you get back into doing your schoolwork? SQ3

The focus of these individualized interview questions was to understand the live experiences of virtual middle school students during cognitive disengagement and the causes of cognitive disengagement. This directly aligned with the main research question and the first sub-question. Questions one to three were introductory to establish rapport with the participant and

help them feel comfortable (Moustakas, 1994). Questions four to six eased into the content and allow participant biases and misconceptions to be bracketed (Natow, 2020). Questions seven to nine directly inquired on the research questions of cognitive disengagement. The final two questions previewed a solution to cognitive disengagement.

Individual Interview Data Analysis Plan

The goals and research questions were in front of me during each step of the analysis process to ensure that the research focus was narrow and aligned (Saldaña, 2021). As the human instrument, the epoché stage was essential to begin each segment (Moustakas, 1994). After bracketing my initial perspectives, I fully reflected on my own experience of the cognitive disengagement phenomenon; likewise, the analysis of the individual interviews began by transcribing the conversation verbatim into Microsoft Word (Moustakas, 1994). Next, the interview was segmented by who was talking, and pre-codes were added to any blatantly apparent insights (Saldaña, 2021). After, I rewatched the recording and documented non-verbal gestures and actions to the verbatim transcript because these were also important insights into a participants' metacognition and feelings; therefore, accuracy in documenting was critical (Kouritzin, 2002; Pi et al., 2021).

The following steps involved the refinement of the analysis process. From the verbatim transcript, each segment of one thought (essentially line-by-line) was isolated into its own row of a three-column table: raw data, preliminary codes, and final codes, respectively (Moustakas, 1994; Saldaña, 2021). Interview scripts were printed out to hand-analyze by highlighting in a color-coordinated manner for preliminary themes. It was also important to distinguish what participants experienced and how the situation or environment influenced their experience. This is known as textural and structural descriptions, respectively (Creswell & Poth, 2018). I added a

TD for textural descriptions or SD to structural descriptions along with the highlighting. Additionally, a first cycle of the imaginative variation stage was employed for comparing the individual interviews against each other in a search for commonalities (Moustakas, 1994; Saldaña, 2021).

Questionnaires Data Collection Approach

Questionnaires were used for the second data collection method as they allowed participants to reflect and respond thoughtfully to open-ended questions (Truijens et al., 2022). The questionnaire was a brief Google Form that was sent to participants after they have met satisfaction with the verbatim transcript from their individual interview. Participants had two weeks to complete the questionnaire. The Google Form platform was selected as participants had the option to either hand-write or verbally dictate their responses. Likewise, middle school students tend to engage more when given virtual investigations (Gnesdilow & Puntambekar, 2022). Rigel virtual school students are familiar with Google Forms, so the risk of increased extraneous cognitive load was low (Bahari, 2022). The questionnaire questions can also be located in Appendix I.

Table 2

Questionnaire Questions

Thank you for taking the time to thoughtfully answer these questions that will explore *how* you learn and *what helps* you learn. There are no right or wrong answers as this is your perceived learning, so please feel empowered to answer honestly and thoughtfully. At the end of the questionnaire, you will have an option to send a copy of your responses to your own email. Otherwise, a copy will be sent to you afterward by Mrs. Gerrels.

1.

Lesson 3: Moon and Planets

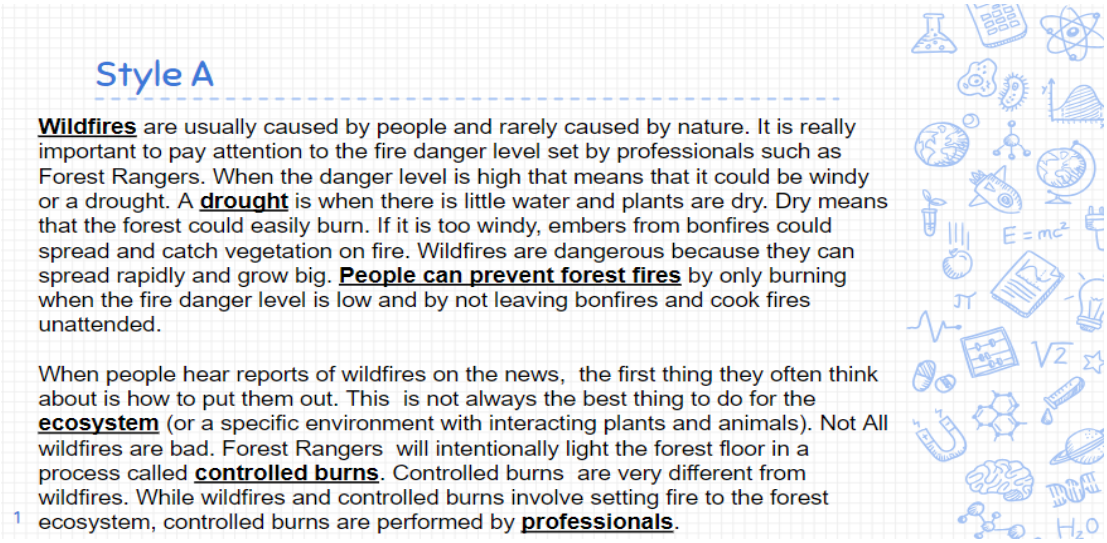
Objective 3

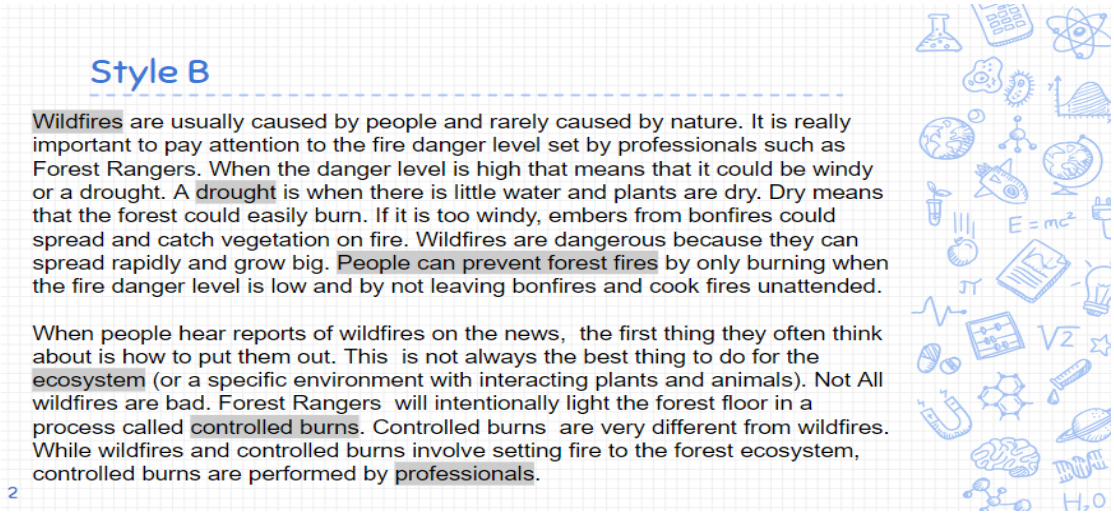
In this section, you will compare and contrast Earth and its moon.

First Think, then Write: What do you already know about the Moon compared to Earth? What is the Moon's atmosphere and temperature like? Would you weigh the same as on Earth?

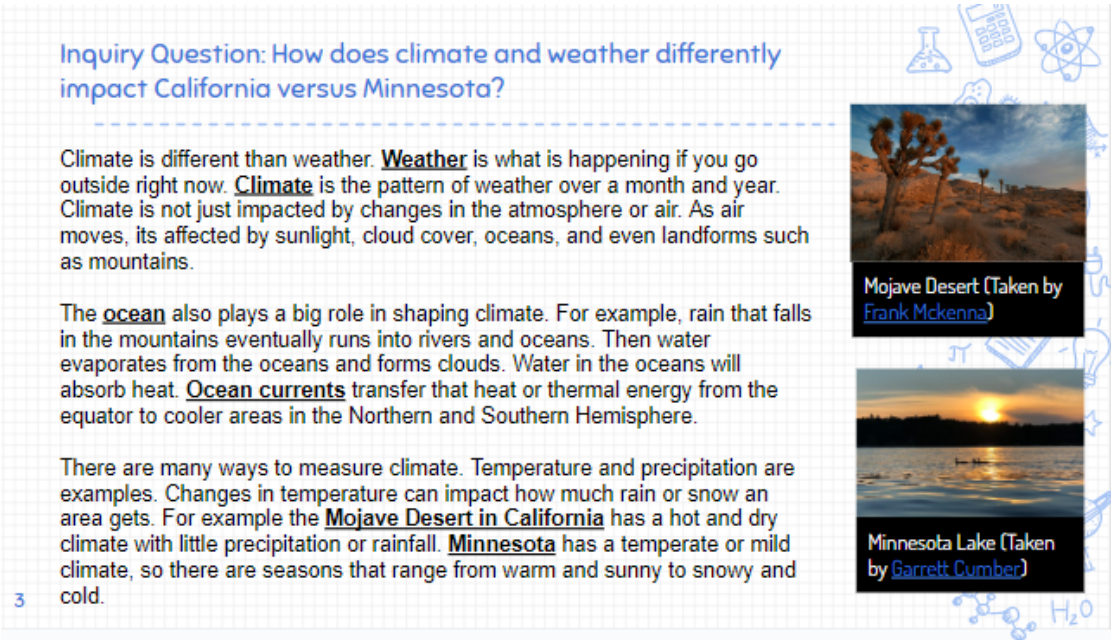
The question will have the above picture of a typical science lesson guide and the lesson objective. The picture is from a note guide created by the researcher. Explain in detail how you would complete a typical lesson. CRQ

2.





The question will have two pictures (above) of a lesson of the same science topic but in two different formats. The text was composed by the researcher. Compare and contrast the two lessons. Which style would help you learn more and why? SQ1

3. 

The question will have a picture of the above lesson with an inquiry question. (Note: The text was composed by the researcher. The pictures have free user license from Unsplash.com. The Mojave Desert, California was taken by Frank Mckenna and the Minnesota Lake was taken by Garrett Cumber). Your teacher asked you to help your classmate learn this topic. How would you help your classmate understand the important information? SQ2

4. This question will begin with a video that demonstrates different types of signaling (identified by lettered slides) of the important information. [Script from video: Slide #1 Hi, Scientists! In this question, you will be shown a series of slides with different types of signaling or cues. First, you need to identify the two objects that are important for each picture. Then, you will reflect. What letter of the slide was your favorite and why?

Remember the reflection is more important than getting the images correct. You may pause and replay this video as many times as you like. Remember to document how many times you watched the video in the description. Slide #2 Here is the original image. (I will use to the cursor and read each image aloud: satellite, cowboy hat, airplane, pterodactyl, clock, pine trees, cartoon, fire hydrant, cat, stingray, cherry trees, river, dragonfly, jeep, phonograph, dog, donut, horse, observatory). Slide #3 Style A- Bolding; Which two objects are important? Slide #4 Style B – Highlighting; Which two objects are important? Slide # 5 Style C – Icons; Which two objects are important? Slide #6 – Style D – Blurring; Which two objects are important? Slide #7 Style E – Instructor Pointing; Which two objects are important? Slide #8 Style F – Instructor Arrows; Which two objects are important? Slide #9 – Instructor Circles; Slide #10 – Instructor Voice inflection or emphasis; Which two objects are important? Slide #11 Great job! You may rewatch this video as needed. Please be as detailed as possible in your reflection. Which Slide (Style A-H) was your favorite and why?]

   a. Link to unlisted video (embedded into Google Form): https://watch.screencastify.com/v/iwYj4dLt713A4M5UrdJj (Note: this video and the slideshow was made by the researcher).
   b. Link to unlisted slideshow: https://bit.ly/QuestionnaireSlideshow
   c. How do you know what information is important?
   d. What letter of slide was your favorite and why? SQ3

5. Reflect on how you completed this questionnaire. Here are some questions to think about as you provide a thorough explanation of your process. CRQ

a. **How** did you complete this survey in one sitting or multiple? If multiple, what caused you to stop in between? SQ1
b. **Who** (if anyone) helped you and how? SQ2
c. **Where** did you complete this questionnaire? CRQ
d. **What** type of device did you complete this questionnaire on? SQ3
e. **What** else do you wonder, or did you think about your learning process? CRQ

This questionnaire was built to focus on quality of responses and correlate with each of the research questions. The first and fifth question were related to the central research question. The second question was related to the first sub-question. The third question was related to the second sub-question while the fourth question was related to the third sub-question. This provided a comprehensive view of the lived experiences of virtual middle school students in fulfillment of the purpose.

Questionnaire Data Analysis Plan

After bracketing my own perceptions and contributing to the audit journal, I began to transpose the questionnaire responses into a notes document. First, I looked at question five to understand the environment for which the participant completed the questionnaire. Question five provided structural description of the experience (Creswell & Poth, 2018). Next, their verbatim responses were transcribed and organized by research question into a graphic chart (Moustakas, 1994; Saldaña, 2021). After the preliminary codes were complete for the questionnaire data section, redundant codes and overlap were sought against the individual interviews (Saldaña, 2021). A copy of this analysis was sent to the participant via WebMail so he or she had the opportunity to verify their response was captured appropriately or make addendums to their thoughts. If response questions were difficult to discern, a follow-up interview occurred.

Focus Groups Data Collection Approach

The third data source method were focus groups. Creswell and Poth (2018) expressed that focus groups can be an effective option for participants whom share an experience (such as this phenomenology investigation) or whom are shy. Virtual education has become an ideal option for families looking for an alternative to brick-and-mortar settings; students find solace from bullying or coping from social anxieties along with the accelerated or credit recovery options (Barbour, 2022). The focus group option allowed peer support and unity in the shared experience. On the other hand, this situation may have led to students sharing different experiences. These contradictions provided rich insights into the research and sub-questions.

Group sizes will depend on the number of recruited 12-15 participants. Smaller groups will promote participation and ensure that all perspectives are included (Beeman, 2022; Creswell & Poth, 2018). From the qualified applicants, there were five eighth graders and ten seventh graders. The five eighth graders were grouped together. The seventh graders were sorted randomly based on their time selection of availability. The hour-long session took place in the Zoom Class (LiveLesson) virtual classroom. Participants were on webcam, used their microphones, and the chatpod. Similar to the individual interviews, the focus group was semi-structured with open-ended questions. The researcher took on the role of "participant as observer," to keep the conversation moving, present all questions, and confirm all participants had an equal opportunity (Creswell & Poth, 2018, p. 167). Questions were shared on the screen and read aloud. Like the other methods, the recording was housed within the company's dual-verification server. Participants were given pseudonyms for confidentiality within the research data. The focus group questions can also be found in Appendix J.

Table 3

Focus Group Questions

1. Greetings, Scholars! Thank you all for joining today. I greatly appreciate your time. As we begin, we have a few group norms to review. This is a safe space, and your identity is important. Please use the pseudo names of others. We will respect all ideas because there are no right or wrong answers. We are investigating your personal experiences with disengagement or losing learning focus. Reminder that these conversations are confidential and information here should not be shared elsewhere. Please feel empowered to be honest and speak up. To try our best not to interrupt each other, we will use the hand raise feature. After you share, please lower your hand. Are there questions, comments, or concerns on the norms?
2. Think about when you are completing an online lesson. What causes you to disconnect from completing that work? SQ1
3. How do you know what information is important in a lesson? CRQ
4. You experienced several different types of signaling in the Questionnaire (shows list of examples on the screen). In your opinion, how did these cues impact your learning? SQ3
5. Our brains have a limited capacity to process new information. Explain a time when you felt overloaded with information. CRQ
    a. Follow up: In your experience, how have you reengaged after feeling disconnected? SQ2
6. You have done a great job. We have one more formal question. How can cognitive overload be prevented? SQ3
    a. Follow-up topics: lessons organized, your role, your learning coach's role, your

teacher's role CRQ

7. Thank you so much, Scholars! I greatly appreciate your time. Is there any final thoughts or insights on your own learning or what helps you learn that you would like to share? CRQ

Middle school students are able to converse in small groups and articulate their perspectives coherently (Abraham et al., 2022; Barney & Leavitt, 2022; Bone et al., 2023; Liu et al., 2022; Semeraro et al., 2020; Webb et al., 2022). Question one was essential to establish expectations and create a productive environment (Creswell & Poth, 2018). Questions two and three were written to build collaboration, trust, and allow participants to reflect in a different way than during the observation or follow-up interviews. Questions four and seven addressed the main research question on cognitive disengagement while questions five and six directly related to the sub-questions regarding signaling. Finally, the concluding questions eight and nine provided data on preventing cognitive disengagement.

Focus Group Data Analysis Plan

Focus groups were the final data collection method, and the analysis plan was similar to the previous methods. After bracketing my own perceptions, field notes were procured, and dialogue were typed verbatim into Microsoft Word from the recordings (Moustakas, 1994; Saldaña, 2021). During the first cycle, refining both resources began as I merged the field notes and dialogue timelines (Saldaña, 2021). After, I rewatched the recording and documented the non-verbal gestures and actions to produce the most well-rounded encapsulation (Kouritzin, 2002). Next, extraneous filler words were removed, and each conversation section were segmented until they were isolated with one code (Creswell & Poth, 2018). Again, this data was printed as well as initial highlighted, textural and structural descriptions identified, and

preliminary coding performed (Creswell & Poth, 2018; Moustakas, 1994; Saldaña, 2021). Imaginative variations were employed and added to the researcher's memos; however, only the participant data was coded (Moustakas, 1994; Saldaña, 2021).

Data Analysis

As the data collection involved other digital programs, using an online Qualitative Data Analysis Software (QDAS) was an appropriate incorporation for the second cycle (Saldaña, 2021). Atlas.TI was used to organize and manage the data analysis that had already been performed independently across the three separate sections. The QDAS assisted in intentionally searching for connections among all the data and locating areas of overlap that were missed during the first cycle analysis (Saldaña, 2021). Searching and word recognition led to organizing data into new codes that expanded all three data collection methods (Saldaña, 2021).

The second cycle (or synthesis phase) involved creating a restructured description of the phenomenon from the collected text (Moustakas, 1994; Saldaña, 2021). In particular, the textural and structural descriptions were sorted into a two-column organizational chart as another layer of analysis. The use of Atlas.TI was beneficial when trying to "cluster the invariant meaning units into themes," (Moustakas, 1994, p. 122). Once the third column of final codes were applied, themes or "essences of the experience" was elicited (Moustakas, 1994, p. 123; Saldaña, 2021). The themes were linked back to the research and sub-questions.

Trustworthiness

Extensive measures were taken to ensure the research was trustworthy or without the researcher's influence (Lincoln & Guba, 1985). Due to the human component of qualitative investigations, objectivity of the research is frequently under scrutiny from the positivist

perspective (Shenton, 2004). Lincoln and Guba's (1985) lens was ideal in this study for combatting the positivist paradigm as their framework has established a comprehensive validation structure. The following section discusses how credibility (truth value), transferability (applicability), dependability (consistency), confirmability (neutrality), and ethical considerations were met in this transcendental phenomenological investigation (Guba, 1981).

Credibility

Guba (1981) related credibility to internal validity or truth value; this category compares the raw data and the phenomena of which the data represents. Before beginning my investigation, a thorough examination of the previous research was performed as outlined in the Literature Review of Chapter Two (Shenton, 2004). In order to obtain credibility, the participants' perspectives needed to be represented with integrity and precision (Lincoln & Guba, 1985). Credibility was accomplished in my investigation through triangulation, peer debriefing, and member checking.

Triangulation

According to Farquhar et al. (2020), triangulation is a best practice for phenomenological qualitative research due to the overlapping and thorough analysis of various perspectives. Triangulation is the use of multiple approaches in order to obtain a holistic understanding (Shenton, 2004). The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. Triangulation was integrated in the data collection through individual interviews, questionnaires, and focus groups. Additionally, this order has been carefully selected to ensure that both researcher and participant biases were properly bracketed prior to analysis (Creswell & Poth, 2018; Moustakas, 1994; Natow, 2020).

Triangulation was utilized in the process. Shenton (2004) recommended thorough preliminary research, rich descriptions, and frequentative questioning. Rich detail of the phenomenon was amply provided within the process and data collection descriptions. Likewise, inquiries within the study were asked in various ways to participants so that internal validity could be apparent.

Peer Debriefing

Another significant component of qualitative credibility is to prove that there has not been influence from the researcher (Lincoln & Guba, 1985). Peer debriefing was used to ensure accountability. I planned to have colleagues (who hold either a master's or terminal degree) to review my research throughout the process due to their expertise in qualitative methodology. While my dissertation Chair and Committee Member also be provided insights in drafts, my colleagues were detached from my research; yet as they are versed in the qualitative research methodological process, they were able to identify gaps and provide a fresh perspective for improvements.

Member Checking

According to Lincoln and Guba (1985), member checking is the most essential component in achieving credibility. Member checking involves verifying that participant perspectives are represented with finesse and accuracy (Shenton, 2004). This happened at multiple critical times throughout the data collection and analysis process. After transcribing the individual interview verbatim, I sent a transcript to the participant for review. Likewise, participants had the opportunity to review after the first and second cycle of coding (Saldaña, 2021). The focus group verbatim transcripts included all member contributions; however, all members had a pseudonym except for the participant reviewing the document. Volunteer

participants had the ability to change, redact, or confirm any of their statements at any injunction. Additionally, participants were solicited upon summarizing of the themes to ensure their perspectives were represented appropriately.

Transferability

Guba (1981) referred to transferability as applicability, external validity, or generalizability. Transferability was embedded when situational and time restrictions have been removed and cross-variations of findings have been incorporated (Guba, 1981). Thick descriptions of the phenomenon were used in order for this research to maintain composure if applied to another situation (Shenton, 2004). I provided a detailed background that included descriptions of the virtual environment and platforms used as well as the investigatory procedures followed to achieve transferability (Lincoln & Guba, 1985). The aforementioned triangulation also contributed to the robustness of this research for transferability's sake. In addition, Singh et al. (2021) included participant profiles in order to confirm that the research was trustworthy, but the authors warned that cultural context may prove to be an obstacle for transferability. To rectify this concern, specifics regarding participant culture and demographics were included while maintaining confidentiality.

Dependability

Another component that bolsters credibility is dependability. This category is connected to reliability or consistency (Guba, 1981; Lincoln & Guba, 1985). Throughout my research, I planned to enhance the details of procedural description by simultaneously documenting (or journaling) the project. Dependability was attained in a few ways. Along with the thick descriptions, I added explanations and metacognitive analyses in an audit trail during both the data collection processes and the coding analysis (Saldaña, 2021; Singh et al., 2021).

Furthermore, my dissertation Chair and Committee Member were stable readers throughout the process which provided another consistency (Singh et al., 2021).

Confirmability

Objectivity or neutrality are comparable terms with this category of confirmability (Guba, 1981). Shenton (2004) explained that confirmability includes triangulation and the audit trail- both of which will be data-centered. The goal of confirmability was to convince the reader of my objectivity through the acknowledgment and segregation of researcher biases and influential judgments (Singh et al., 2021). Lincoln and Guba (1985) deemed reflective memoing as vital so that the research is credible. I planned to use a scaffolded Microsoft Word document as a running blog template. The document provided thorough evidence of the environment and steps of accomplishments, and insights into my bracketing and metacognition for each entry (Moustakas, 1994; Shenton, 2004; Singh et al., 2021). Likewise, explanations and justifications of decision-making were included within the audit trail (Shenton, 2004). Outside of the reflexive documentation, the raw triangulation data and cycles of coding were included in the research (Moustakas, 1994; Saldaña, 2021). Furthermore, there was substantial review from participants, peers, and directors to ensure a comprehensive execution was achieved.

Ethical Considerations

This transcendental phenomenological qualitative research was infused with ethical considerations in regards to the site, participants, confidentiality, and securities. First, no data was collected until both Liberty University and the governing authorities of the virtual school site granted Institutional Review Board (IRB) approval. Rigel virtual school resides under the parent company (Orion); therefore, permission was needed from Orion's Director of Efficacy and Research, the Executive Director of Rigel, and Rigel's Assistant Principal of the middle

school. In an August 2, 2022 email, all three authorities provided preliminary written agreement to conducting this research in alignment with permission from Liberty's IRB.

Permissions

The researcher obtained both Liberty and the site's IRB approval prior to the initiation of any data collection. Site approval was needed from both the parent company (Orion) and the virtual school (Rigel). Liberty's IRB approval was obtained on August 31, 2023 (included in Appendix A). Both Orion and Rigel provided approval in a July 2023 email (included in Appendix B).

After all required approvals had been received, the researcher began recruiting the second week of September 2023. The student recruitment flyer can be found in Appendix C while the parent recruitment letter can be found in Appendix D. Furthermore, the participant screening phone call and questions can be found in Appendix E. As participants were under the age of 18 years old, the student assent form is located in Appendix F, and the parent consent form is located in Appendix G.

Other Participant Protections

Preserving social responsibilities and dignity for all individuals involved in this research will be of utmost importance (Creswell & Poth, 2018). Another reason IRB approval was obtained first was to confirm clear understanding and transparency of the presented research. During recruitment, I wanted to guarantee that participants fully comprehended their involvement preemptively rather than retrospectively (Arnaldi & Bianchi, 2016). Likewise, participants maintained a volunteer nature throughout the investigation with the ability to opt out or refrain from answering at any point in time. As the volunteer middle school participants were minors (between 11 and 14 years old), both assent and parent or guardian consent needed to be

attained. Moreover, all participants were treated with dignity and respected throughout each and every interaction. Communication of the timeline, involvement, and process were frequent so that researcher-participant professionalism was maintained as well as validating study boundaries (Gonzalez, 2015; Waelbers, 2011). Similar to the site's anonymity, confidentiality was preserved with participants as they had pseudonyms and extra care was taken to safeguard against identifiers (particularly with special learning needs).

The low risks and high benefits were thoroughly assessed as the well-being of participants was of supreme priority. The virtual site and volunteer nature of participants contribute greatly to low risk. Participant identification was only known to myself. During the focus groups, participants may have had the risk of being identified on webcam by other participants. This was mitigated with multiple reminders outlined in the participant agreement and the established focus group norms. As outlined in the data collection, participants changed their names to their pseudonyms prior to the focus group discussion, so other participants would not know their real names. These middle school participants were not my current students; therefore, there was no risk of academic ramifications. On the other hand, participants may have felt frustrated, uncomfortable, or upset during the activities as the purpose of this transcendental phenomenological study was to understand the lived experiences of virtual middle school students during cognitive disengagement and signaling. Through assent (and consent), participants (and guardians) fully understood their ability to opt out of the question, activity, or full study at any time.

In contrast, there were many benefits for participanting. These virtual middle school scholars could have gained insight into how they learn. Participants could potentially share this understanding in future learning settings to optimize their experience. Moreover, participants

may have learned the causes of their cognitive disengagement and (potentially) remedial strategies. Metacognition may have been another learning skill that was developed. When learners were prompted to be metacognitive, they could more readily apply their reflective processing in future situations (Brown & Green, 2020; Clark & Mayer, 2016). Participation in this study had zero impact on their academic performance, so participants were able to benefit from learning, trying, and possibly failing without academic consequence. Furthermore, the practice of skills and learning processed from this study could develop a more effective relationship and mindset with learning for the participant (Dweck, 2017).

Security is another ethical consideration that has been thoroughly vetted. The majority of the data was in the digital form; however, physical data (such as the printed verbatim transcripts) has been housed in a locked cabinet within my personal home office. Per Liberty's IRB, the physical data will be destroyed after three years unless further research is confirmed within said duration. Then, the physical documents will be destroyed within five years. I do not share the lockable office. The digital data has been secured under three unique passwords: the site's laptop, the site's Google Suites, and the site's educational portal (or platform). As mentioned in the data collection methodology, recorded interactions are housed within the educational portal with the means of an additional password protection. Moreover, secured Orion's webmail and secured Liberty's email was utilized for all transcript and draft communications. Finally, the laptop remained within my locked home office.

Summary

This transcendental phenomenological qualitative investigation was ethical and trustworthy based on the participant-centered research method (Guba, 1981; Lincoln & Guba, 1985; Moustakas, 1994). The purpose of this transcendental phenomenological study was to

understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. As evident in this chapter, the methods utilized accomplished this purpose through the triangulation of the three different data collection methods: individual interviews, questionnaires, and focus groups (Creswell & Poth, 2018; Farquhar et al., 2020; Shenton, 2004). As the human instrument, the researcher continuously bracketed biases and prejudgments to ensure the data was analyzed with a fresh perspective each time (Moustakas, 1994). Furthermore, the data was carefully reviewed and scrutinized in multiple ways based on foundational frameworks of Moustakas (1994) and coded using Saldaña's (2021) method. Along with thorough textural and structural descriptions, successful completion of this investigation was achieved once saturation of the data was confirmed among the participants' responses.

CHAPTER FOUR: FINDINGS

Overview

The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. In this Chapter Four, detailed profiles of the participants are presented. This is followed by a thorough presentation of the three resulting themes and their corresponding two subthemes: student empowerment through virtual learning (theme), freedom to learn, student driven, cognitive threshold processing (theme), metacognition, the rogue brain, virtual learning strategies (theme), augmenting modalities with multimedia approaches, and effective signaling for virtual learning. Additionally, there were two distinct outliers: taking breaks and being set up for success. These two outliers were shared lived experiences for all 15 participants; however, they did not directly answer the research questions. Next, the central research question and three sub-questions are addressed. The chapter concludes with an analytical summary of the triangulated date.

Participants

The researcher was successful in her pursuit of a diverse yet balanced group of participants. The 15 selected students composed an accurate sampling of the larger Rigel school population. Recruitment WebMails were sent to 433 students in Grade 8 and 475 students in Grade 7. Among the 15 participants, 53% (eight) were female and 60% identified as white (nine). Demographic data can be found in Appendix L. During the recruitment, there were approximately 4,071 students school-wide (grades K-12). Overall, 55% of the total student population were female, 67% of the 7th grade population identified as white, and 65% of the 8th

grade population identified as white. A list of the 15 participants can be found in the following Table 4.

Table 4

Student Participants

Pseudonym*	Grade	Age	Gender	Family [Family members (student's place)]
Aquila	7	13	Female	Mom, 2 brothers (youngest child)
Aries	8	12	Female	Dad, Mom, 9 siblings (middle child)
Bootes	7	12	Male	Dad, Mom, 1 sister (youngest child)
Cassiopeia	8	13	Female	Dad, Mom, 2 brothers (middle child)
Columba	7	12	Female	Dad, Mom separated, 4 siblings (middle child)
Draco	8	13	Male	Dad, Mom, 1 sister (youngest child)
Lupus	7	12	Male	Dad, Mom, 1 sister (eldest child)
Norma	8	14	Female	Dad, Mom, 3 siblings (eldest child)
Pegasus	7	12	Male	Grandma, 3 siblings (middle child)
Phoenix	7	12	Female	Stepdad, Mom (only child)
Pyxis	7	13	Male	Dad, Mom, 2 sisters (eldest child)
Taurus	7	12	Male	Dad, Mom, 2 brothers (middle child)
Tucana	7	12	Male	Dad, Mom, 3 siblings (eldest child)
Virgo	8	13	Female	Dad, Mom separated (only child)
Vulpecula	7	12	Female	Dad, Mom, 2 siblings (eldest child)

Note. This table illustrates the 15 participants, their demographic characteristics, and their immediate family members.

* Pseudonyms were assigned randomly to protect the identities of the participants. In alignment with the celestial theme, pseudonyms are constellations. There are no identifiable connections to the participants' given name, gender, race, or family connection.

Aquila

Aquila is a female, seventh grade scholar. She described her household as, "Well, it's definitely chaotic. It's currently just me, my mom, and my two oldest twin brothers that live here. There's always something fun or random going on, and then I have friends over a lot." Aquila is an avid soccer player who also enjoys reading and drawing. "I'm on my fourth series of my favorite book series ever. It's the *Warrior Cats* book series. It's amazing. I love it." Coming from an in-person school, Aquila joined [Rigel] as a result of the COVID-19 pandemic. "I liked my [in-person] school. I liked being with my friends like all day almost every day, but then my fourth-grade teacher was amazing! She was like one of the main reasons I *stayed* [emphasized] at [Rigel] that year. Otherwise, I—like immediately after COVID—woulda [*sic*] gone back to public school." Aquila is a driven scholar who wants "to go to vet school" and has a rigorous routine which involves working at a "horse ranch" a couple times a week. She is a great note-taker who utilizes signaling "because I color code *everything* [emphasized]." Aquila focuses better in quiet areas, and "I always have music on."

Aries

Aries is a female, eighth grade scholar who lives with her parents and many of her nine siblings. She is a confident learner because "I skipped a grade, so I'm a year younger than everybody else my age." Aries described herself as "an open person. I like every single subject; everything's interesting to me." This is her first year at Rigel. Before becoming a virtual student, Aries was educated through distance learning as well as brick and mortar. She expressed, "I

really like [Rigel] because you can like engage in online activities, talk to people, and do your work whenever. And, it's not that much work, and the work is really easy." Aries takes notes and utilizes many signaling strategies herself (particularly highlighting). According to Aries, cognitive disengagement is "maybe when my learning mindset slightly goes off. Maybe when I'm thinking about like other things." A solution for her is "when there are too many notes and I literally have to get up and walk outside to reload my brain."

Bootes

Bootes is a male, seventh grade scholar who has moved across states with his dad, mom, and younger sister. He explained that he "likes watching Anime. I like playing all sorts of different video games," and is a "morning person." Likewise, Bootes shared, "I've also noticed something through my entire life: I'm a collector." Some of his collections include rocks, books, Squishmallow, and Funkle Pops. Bootes began in brick and mortar and transitioned into virtual learning as a result of the COVID-19 pandemic; however, his family stayed at Rigel because they enjoy the manageable schedule, high rigor, and "being able to reach out to teachers anytime." Bootes has a good understanding of his learning preference.

> My father's brain is like this too, but we don't have to repeat stuff. In normal school they have to drill the information into you by repeating it over and over. I would read it once and then it's like in my head for the next seven weeks.

In the focus group, Bootes shared that he is "definitely an auditory learner" as lesson content can be confusing until "my mom will say it in a different way and then it completely unclicks in my head like someone just turned a key."

Cassiopeia

Cassiopeia is a female, eighth grade scholar who lives with her dad, mom, older brother, younger brother, and dog. She has been a virtual student at Rigel since second grade and continues to be very active. Cassiopeia plays (or has played) tennis, volleyball, basketball, and has many "medals for wrestling." Previously, she attended an "in-person public" school. Cassiopeia shared, "I really want to do nursing because my grandma was doing nursing…I want to try to graduate a year earlier if I could." Her notes typically follow the study guide which include test content and emphasize keywords. Cassiopeia described cognitive disengagement as "when I get really upset because I couldn't figure the question out, so I get really upset and mad," which can be caused by lessons that, "I think it's very hard…or got really boring." To combat this, she will "walk away from the computer and go get something."

Columba

Columba is a female, seventh grade scholar in a blended family with many pets, "I have one cat, one dog, and three rats." She communicated:

> I play guitar. I'm still a beginner, but I do play guitar. I kind of sketch randomly. I like reading, and I like writing, but I'm not the best at it…It really depends on what mood I'm in, but recently I've been sketching hands more and actually gotten pretty okay at it.

For elementary school, Columba attended an in-person school or "the public school here in my area. Yeah, I did well there, but I wasn't really challenged, which was weird. It was honestly really disappointing. But then, I came here, and I actually got to do advanced classes." Columba thrives at Rigel virtual school because, "there are videos that I can watch and listen to for school, and listening is one of my main ways of learning and reading, and that's basically a lot of online school." She utilizes many best practice strategies in her extensive notes such as colors,

questions in the margins, and drawings." Columba metacognitively reflected, "While reading those [websites] I was kind of thinking of how I would phrase things in my essay, but it was actually writing my essay where those things that I had thought of for me, thing that I would use in the essay, my brain pulled a blank. That happens a lot too, unfortunately. I have an awesome brain, and I know that, but sometimes my brain just doesn't brain."

Draco

Draco is a male, eighth grade scholar whose family consists of dad, mom, and an older sister. He explained, "I'm pretty basic. I play games…I also do taekwondo. Black Belt." Draco started at a brick-and-mortar school then "COVID happened, screwed up everything," and he did distance learning before joining Rigel. When asked to compare being a virtual learner, Draco shared:

> Honestly, I take a lot of pride in it. Just me personally. It's kind of just—you know—like it works for me basically. I think it's an awesome concept. It works for me because basically I make my own schedule, and I don't waste six hours a day rotting away in a classroom.

Draco was not inclined to take notes but does now for math because notetaking is required. He was able to identify signaling and does not have a preference. Draco describes cognitive disengagement as:

> There is no sound, first off. I don't know how hot it would be sound, but second…it kind of just feels like—when going back to what I said earlier—unless it's kind of like just not clicking with me. I'm not getting it. I kind of get bored: open, honest.

To help reengage with content, Draco will "kind of skim over everything, looking for summaries. If I don't, like something doesn't click with me, I go back and read that again. Usually."

Lupus

Lupus is a male, seventh grade scholar who lives with his parents, younger sister, and two dogs. Along with an impressive computer race set, Lupus shared:

> I shoot trap, and I recently—I think I told you—I joined the [local] trap team. I used to play football. I'm part of the FLL or First Legal League. I do it with my friend, and then I have a programming thing at six. That is Python. I run a YouTube channel, I guess, and I guess I like Legos.

Lupus enjoys virtual learning better than his previous in-person school, "because you have to wake up at like six in the morning," and had to "sit in classrooms [the] entire day, doing like endless sheets of homework." Additionally, he experienced distance learning during the COVID-19 pandemic and shared that it was "not fun" because "I would be done with my schoolwork, and I would have to sit in the [virtual] class. And, they tell me to do the schoolwork, and I told them I already did it. And, they'd say, 'Do it again'." Lupus does not take many notes as he uses his "second monitor" to complete lesson assessments. Furthermore, his efficient use of time is evident as Lupus expressed, "Yeah, staying in bed for ten minutes will delay everything else by ten minutes. The more time you waste, like fidgeting with your window or whatever, the more time taken away from doing something that you want to do."

Norma

Norma is a female, eighth grade scholar and eldest participant as well as the eldest sibling of four. As the family has moved due to her parents' line of work, she has attended several

different types of schools (such as Montessori and private). Currently, Norma is the only sibling attending Rigel virtual school which works well for her because "it's a lot more flexible where I like to shift my school day a bit. I usually wake up later because I go to bed too late." She has an efficient school routine that includes:

> a break at like two or three for my workout and shower and everything. Walking my dogs, and then, if I have any math or anything left, I just finish that from like four to six because the kids are home by then.

Norma held up her highlighted and organized notes while sharing, "I take handwritten notes on my beautiful little clipboard." In terms of re-engagement, Norma expressed:

> I think I just have to realize that I was zoning out. Actually acknowledge, the fact that I was so I can try to get back on track, and if I can't, then that's when I would take a break and then try again.

She spoke succinctly during the individual interview on mic and chose to only use the chat feature during the focus group.

Pegasus

Pegasus is a male, seventh grade scholar who lives with his grandma, many pets, and is the middle child of four. Pegasus shared, "I have a motorcycle helmet, which is down on my feet. I have a mountain bike. I'm basically telling my whole story of my life." He is extensively involved in his community between horseback riding, volunteering at "an old World War II museum," swimming at the YMCA, and "bowling to practice [with] my high school bowling team." Pegasus attended an in-person public school, and then "Before COVID started, we were required to go to online school after a while of wearing painful masks, and I then think that's the only school that I've been to." He described Rigel virtual school as being:

> pretty fun because I have a problem about learning. Where like, if there's a lot of kids goofing around me, I tend to do it too. So, if there's kids around me, I can't focus good. So being here, I focus really good.

Pegasus's typical school routine is as organized as his dedicated school room which has extensive folders for subjects; "I have whiteboards for math." He reflected that note-taking is "very stressful because I would have to write down a lot of information." During the focus group, Pegasus shared, "Yeah, that's [me] too, my ADHD. I find myself running around the house." This was visually represented as throughout the focus group, Pegasus grabbed objects or moved about the room.

Phoenix

Phoenix is a female, seventh grade scholar who lives with her mom, stepdad, and dog. She provided the most insights of all the participants beginning with a two-hour individual interview. Phoenix shared, "I might give you certain scenarios of my learning personally because my mom thinks I might have some type [of] ADHD because she has it." Phoenix expressed, "I like Disney movies…I like reading. I read at a 12th grade level. It's actually an 11.8, if you want to be specific." Her mom transferred her to Rigel virtual school in second grade "because—as you know—I wasn't being challenged. I was reading more advanced books…she [mom] didn't want me to digress." Phoenix takes extensive notes with signaling such as color "…because it [colors] can help you connect information and ideas. You don't have to sift through all of your notes trying to find it [important information]." Likewise, Phoenix was able to articulate her learning process in great detail. She shared, "Learning is me having a good grasp of what they're trying to communicate. I know what they're trying to communicate. I know what they're trying

to say. I'm not having to decode any inferences," and "Oh yeah, I know [paused] me and disengagement have had pool parties."

Pyxis

Pyxis is a male, seventh grade scholar who lives with his parents, younger sister, and many pets (three dogs and eight cats). This is Pyxis's first year at Rigel virtual school and is coming from an in-person public school. He enjoys "playing video games for one. Sometimes just hanging out with my little sister. She just wants to hang out with me. She just makes me watch YouTube videos with her." Pyxis explained he enjoys hands-on learning, "Last year, I got pretty excited cause like we got to make stuff. We made a homemade magnet." He is not inclined to take notes. In regards to identifying important information, Pyxis shared, "I don't really know how to like describe it. I just know." Pyxis completed the individual interview and questionnaire. On the questionnaire, he wrote, "I wanted it to be done and over with," and "Didn't wonder much," about his learning process.

Taurus

Taurus is a male, seventh grade scholar who lives with his parents and is the middle sibling of two brothers. He enjoys going, "outside climbing, and sometimes I read books. My favorite book is *Archie*," or Taurus will "watch TV or play videogames," such as "*Diablo 2* and some *Zelda* game and some old retro *Zelda* games." Before attending Rigel virtual school, Taurus expressed, "I learned at home." He enjoys virtual learning because, "I can just click on lesson and actually do it. It's a lot easier." Taurus shared how he includes signals into his own notes by stating, "Sometimes I draw arrows to which one [math information] should be added." He also has strategies to combat cognitive overload. "When I take a break, usually I get some food, and after, when I'm done eating it, I try to relax my head. Yeah, and then after that, I'll go

back with a refreshed eye." Taurus only completed the individual interview with his mom being present. She provided minor interjections when Taurus would look to her.

Tucana

Tucana is a male, seventh grade scholar who lives with his parents and three younger siblings "on 40 acres in the country in the middle of state forest." Along with enjoying "four wheelering," Tucana likes "freestyle, like *Minecraft* [or] *Roblox*" gaming. He also described himself as a "car guy" who likes Legos. Previously, Tucana attended an in-person public elementary school. In terms of future schooling, Tucana shared:

> My dad's thinking how he's going to do it. He wanted to try at least one year of homeschooling or online schooling. He likes it a lot, but you know what he always says, 'Us parents, we have to do a thousand times more work because we got to go through every one of your emails, we got to go through all your assignments.'

Tucana has been getting into the routine of this first year at Rigel. He expressed:

> So, we started this year at [Rigel] and all of a sudden, it's *all about notes* [emphasized]. If you don't take notes, *you're done* [emphasized]! I take them. My dad got us some really nice notebooks that have like two different yellow folders, which is very nice.

Tucana has a deep understanding of his own learning, "I'm a good reader. I can read good. I can't do the theme, and I don't like doing that. I like reading for *fun* [emphasized]," as well as "That's like the worst thing about me: taking notes. I have trouble with that sometimes. When I take notes, I tend to write down more of the major thing on each page or just like the keywords."

Virgo

Virgo is a female, eighth grade scholar who shared, "Well, one thing, I'm a Christian, I'm [a] believer in Jesus, and I use that to make a lot of choices in my life. Yeah, I really like reading,

like unhealthy amount of reading." She is an only child with pets who spends equal time at both parents' homes. Virgo also enjoys skateboarding and art. Virgo is coming from a "brick and mortar [public] school" and "was in distance learning" during the pandemic. Virgo shared:

> I really enjoy it [virtual learning]. I can do things at my own pace when I want, and if I get something done, I can work ahead. I don't have to wait for other people to catch up. I think it's good for me right now, but math is a little challenging.

Virgo has as thoughtful routine and typically finishes:

> around lunch. Then I usually eat, sometimes I take a nap, and then just do random little chores, and play videogames in between. Or, if my dad has work, I do work with him. He's a contractor, so he just does a little bit of everything.

Virgo acknowledged, "I don't take as much notes as I should." She strives to problem solve first whether it be in video game puzzles or in lessons. Ideal lessons for Virgo are "lessons that provide a lot of examples and [are] very direct. *Direct* [emphasized]. What it is. I don't do well with learning what it's like or what it's connected to. I want to know what it is."

Vulpecula

Vulpecula is a female, seventh grade scholar who moved states with her parents, younger siblings, and five cats. Previously, Vulpecula and her siblings attended a private school. This is her first year at Rigel virtual school while her siblings now attend an in-person, public school. Vulpecula shared, "I feel like it's [virtual learning] is easier than public or private school because like the lessons are easier, and everything is in one place." Along with enjoying working "at our own pace," she likes not getting "points off…because I didn't show my work because I just did [math] in my head." Additionally, Vulpecula communicated, "I always finished like the things before everyone else, and then, I just doodled in my notebook. And then, I kept getting in trouble

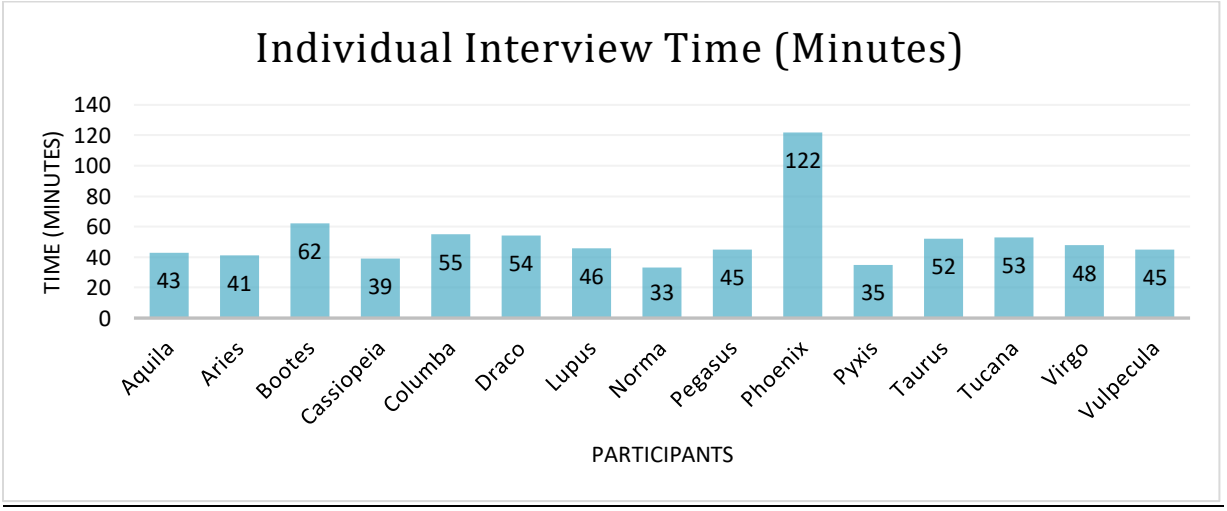
for doodling in my notebook." If she does take notes, "I just write on random pages in the notebook, then get a completely new page." During the individual and focus group interviews, Vulpecula consistently played with a fidget and rarely made eye contact. Regarding cognitive engagement, "Just like sometimes doodling distracts me. Sometimes it helps me focus. Same with stuff like fidgets. Sometimes it distracts me, sometimes it helps me focus."

Results

The following section encompasses the three major themes and six corresponding subthemes resulting from the collective lived experiences of the 15 virtual middle school participants. To achieve triangulation, the volunteer students were requested to participate in a one-hour individual interview, a questionnaire, and a one-hour focus group. Examples of code creation from the raw data can be found in Appendix M and Appendix N. All 15 participants completed the individual interview. As there were no time constraints presented, participants were given ample time to thoroughly represent their lived experiences. The specific length of time for the individual interviews is represented in Figure 1 below.

Figure 1

Individual Interview Time (Minutes)



Fourteen participants (save Taurus) completed the questionnaire. It is worth noting that Pyxis entered an alphabetical pattern (A, B, C, etc.) with his responses for Question 4 which resulted in only one correct identification. He also reflected, “I wanted it to be done and over with.” All 14 participants who completed the questionnaire did so on a computer with five participants specifically identifying their school laptop. Twelve participants indicated that they completed the survey in their typical school study location. Most participants did not have someone else help them. Pegasus’s mom helped him by “reading the questions,” Phoenix’s mom reminded her “not to describe so much about what I do after a lesson,” and Tucana indicated that his dad helped him.

Thirteen participants (save Pyxis and Taurus) contributed to the focus group discussions. Participants were randomly assigned to the Wednesday, Thursday, or Friday focus group based on their selected availability. As the researcher facilitated in a semi-structured manner, interjections were only made to ensure that each participant had an opportunity to answer every question. The Friday focus group discussed for 52 minutes and consisted of Aries, Cassiopeia, Draco, Norma, and Virgo. The Wednesday focus group discussed for 61 minutes and consisted of Lupus, Phoenix, Taurus (absent), Tucana, and Vulpecula. There were technical difficulties for two of the participants at the beginning which caused a delay. It is also worth noting that Tucana’s parents interrupted at the one-hour mark and requested the meeting conclude; however, this did not inhibit results as all participants provided insights for every question in the allotted time. The Thursday focus group discussed for 47 minutes and consisted of Aquila, Bootes, Columba, Pegasus, and Pyxis (absent).

Triangulation revealed three themes with corresponding two subthemes each. All participants shared the lived experience of enjoying virtual learning, battling cognitive

disengagement, and leveraging multimedia (mostly in the form of signals) to prevent or regain focus. Virtual education was perceived to be enjoyable due to the allotted freedoms with the learning process and student driven customizations. Participants had detailed awareness and was able to describe their cognitive thresholds and processing in a metacognitive capacity. Referring to their brain as a foreign entity, participants elucidated the experienced difficulties when the brain goes rogue or acts in contradiction to the desires of the individual. Furthermore, the student-centered nature of online education manifested in the learning strategies presented by the participants. They shared a commonality in utilizing multiple modalities (particularly auditory). While one signaling strategy was not universally recognized as the most efficient, participants shared the perception that multimedia signaling is effective in various capacities when used in resources, by others, or by the learner, themselves. The themes and subthemes are aligned in Table 5 below.

Table 5

Themes & Subthemes

Themes	Subthemes
Student Empowerment through Virtual Learning	Freedom to Learn Student Driven
Cognitive Threshold Processing	Metacognition The Rogue Brain
Virtual Learning Strategies	Augmenting Modalities with Multimedia Approaches Effective Signaling for Virtual Learning

Student Empowerment through Virtual Learning

All 15 participants corroborated that virtual schooling was their preferred method of learning due to the freedoms and learner-centered nature that online education affords. While Taurus cited the “freedom,” Aries shared, “I experiment with drawing and try new stuff,” and Vulpecula enjoyed the ability to “try on my own.” Phoenix proclaimed, “I have more

possibilities to do other things." The participants expressed a shared lived experience that virtual learning was enjoyable, flexible, individualized, and rigorous.

Six participants explicitly indicated that virtual learning was enjoyable. Among the 12 participants who referenced multimedia, Cassiopeia found enjoyment in the "videos" and Columba found enjoyment in the "interactives." Aquila, Bootes, and Tucana appreciated getting to learn on their timeline. Bootes shared, "I'll go play a game for like a bit and come back," and Tucana would "take a break or do something fun, so my brain is reset." Moreover, Cassiopeia emphasized choice for resources:

> I love when they had the book. I do *not* [emphasized] like the book. I like a hands-on book rather than online. I love when they had the book. You can have it yourself—when you're not online…If you want to do it online or on your book.

Many participants thrived on individualized learning and the ability to choose. Along with "fun references," Aries expressed enjoyment in personalizing her learning, "I prefer reading and figuring it out myself, I don't like help or guidance…I don't wanna [*sic*] write down what they're telling me to. I wanna [*sic*] write it down in my *own* [emphasized] words." These sentiments were shared by six other participants. Aquila indicated, "Usually there's a video at the beginning that I watch, and I can take notes on it if I want to." If she thought information "might be helpful, then I write it down." On the other hand, Draco would "just grab whatever makes the most sense to me and throw them into my notes." Pegasus would write down information if he thought "I better write this down" or "when I feel like writing something down." Furthermore, Cassiopeia would not only customize her note-taking but also "pick what pages" she would read.

Participants also shared the perception that their online curriculum was rigorous for their performance level. Over fifty percent of participants were taking at least one enrichment course

such as Honors Geometry or Gifted and Talents Language Arts. Virgo highlighted how she felt empowered:

> Probably last year when we had to write a first-person narrative for English, and he [the teacher] was like, the minimum is one page. I ended up writing eight pages. Way too long, but I really like it in the end. I was in accelerated English last year, and we had to do the little writing prompts on the story every week. Yeah, I was enjoying that, and I was getting more into figuring out how to write things better. When this came up, I got excited because I wanted to write something just longer.

Feeling supported was another shared lived experience expressed by 14 of the 15 participants. Pyxis did not explicitly indicate if he has asked or received help from his Learning Coach or teacher. While the level of support varied depending on the learner, all 14 participants indicated that he or she would try first. Tucana captured this by saying, "I would ask her [teacher] for help after trying a couple times and failing." On the one hand, Draco acknowledged rarely asking for help. "The thing is that hasn't happened a lot." Conversely, Aries shared, "I haven't really been like contacting teachers a lot this year," but she does ask her mom for help. "She's been teaching me how to study and frame everything." On the other hand, parents—as the primary Learning Coach—would help participants navigate technology (like Aquila), problem-solve math questions (like Lupus and Taurus), "read some of the paragraphs" (like Pegasus), discern important information for notetaking (like Phoenix), review for tests (like Virgo), or locate question responses (like Vulpecula). Sometime, support was just a matter of "saying it in a different way" like for Bootes and Columba.

According to four participants, the integration of multimedia also provided support for the development of particular skills. Cassiopeia indicated that the graphics in the "English study

guides" helped show her "what to write down." Norma learned equation problem-solving during direct instruction using "Desmos." Similarly, Vulpecula elaborated on the benefit of explaining while "screensharing." Pegasus said, "Sometimes I would use this app called Libby that would read the book to me."

Freedom to Learn

There was one hundred percent consensus from all fifteen participants that learning in a virtual school setting has been a positive experience. The level of enthusiasm about being a virtual learner varied. Aries, Cassiopeia, Lupus, and Pyxis provided non-verbals of giant smiles when asked how they feel about being a virtual student. Pyxis also gestured with two thumbs up and responded with, "Good." Lupus reflected that virtual learning is, "Fine. I like it." Virgo expressed, "I really enjoy it," while Bootes and Columba stated, "I love it." Two participants found virtual learning fun. Pegasus explained:

> It's pretty fun because I have a problem about learning where—like if there's a lot of kids goofing around me, I tend to do it too. So, if there's kids around me, I can't focus good. So being here, I focus really good.

Additionally, Tucana stated, "I think it's really fun because we talked about [learning at Rigel] over the phone the first time."

Several participants held higher perceptions and preferences for virtual learning over other forms. Aries shared, "I like it way better than like going into in-person school because it does not feel like a school and the teachers, they don't take responsibility for like what the students do." Tucana described the unstructured nature of distance learning while "during COVID we had to do Zoom…everyone was in their jammies" and "a bunch of students were cheering on" a student who asked to "jump in the snow." Later, Tucana shared his frustration

with being finished with the required work and asking the teacher to leave Zoom meetings early. Lupus corroborated Tucana's distance learning experience as he expressed:

> Online is better with being a virtual student…I don't really remember much of distancing learning, but I had to use Google Classroom, which was not very fun. It's not very fun to use Google Classroom. I'd be doing meetings, I'm pretty sure, like ten meetings a day or something. Not ten meetings, but a decent amount of meetings, and I would sit in them all day. And another problem with the distance learning thing was that I would be done with my schoolwork, and I would have to sit in the class. And, they would tell me to do the schoolwork, and I told them I already did it. And, they say, 'do it again.'

While Draco participated in distance learning, he shared, "I'm going to dig deep here. I don't remember a lot of it. I know we had basically daily Zoom meetings." In contrast, Draco promoted being a virtual student. He expressed, "Honestly, I take a lot of pride in it. Just me personally. It's kind of just—you know—like it works for me, basically. I think it's [an] awesome concept. It works for me." Similarly, Phoenix articulated, "I like the privileges of being a virtual student. Like for example, there is more flexibility."

Flexibility of schedule was the leading benefit of virtual learning. This was identified in various ways by 13 of the 15 participants. Taurus, Virgo, and Vulpecula specifically enjoyed being able to complete work at their "own pace." Draco elaborated, "Basically, I make my own schedule, and I don't waste six hours rotting away in a classroom." Later on, he contrasted virtual learning to brick-and-mortar's "pace [being] too fast. Where you know they don't spend a lot of time on something that you really should be spending more time on." Likewise, Aries appreciated doing "work whenever" even "sometimes I get up in the late hours to do it when I feel motivated." Norma's routine supported Aries's statement:

> It's [virtual learning] a lot more flexible where I like to shift my school day a little bit. I usually wake up later because I go to bed too late. I usually wake up from 9[am] to 12[pm], and then I do my LiveLessons and my homework. And then, I take a break at like 2[pm] to 3[pm] for my workout and my shower and everything. Walking my dogs. And then, if I have any math or anything left, I just finish that from like 4[pm] to 6[pm] because the kids [siblings in brick and mortar] are home by then.

Moreover, the atypical start to the school day was confirmed by five other participants. For Phoenix, the later start is because she will stay up late reading, or because "I normally end up doing my routine, and I get lost in my mind in the bathroom or something." For Aquila, the later start is to accommodate "volunteering at a horse ranch" in the morning. In contrast, Pegasus starts earlier than the traditional brick-and-mortar school for his weekly volunteering. Pegasus not only does "horseback riding" but also works at an "old World War II museum," and "swimming" at the YMCA. Along with many extra curriculars (wrestling, volleyball, basketball, and tennis) that Cassiopeia participated in, she indicated, "Sometimes [I wake up] like 10[am] because I couldn't sleep last night until 4[am] in the morning. Had a major headache last night."

The remote nature of virtual learning also allowed participants to work ahead for family trips. Cassiopeia highlighted how her siblings and her attend virtual school so they can "travel as a family more." Pegasus explained, "Basically, I have a few days ahead, and I usually get breaks between lessons, and I'm only getting like one break." Boots and Columba also cited planning ahead for future events. Columba explicated, "I'll look ahead and figure out about how many quick checks or like practice assessments or pages there are in each lesson, and I can sort them out—through the day to fit them."

Thirteen Participants explicitly celebrated the learning independence that virtual learning affords. On the one hand, some participants felt that their learning was not inhibited by others. Virgo shared, “I don’t have to wait for other people to catch up,” and Aries articulated:

> My parents wanted to try and put me into [in-person] Middle School, but I did not like it at all. The people were not put together, and they had business from home. Then, things that were not school related [were] coming into topics and swearing and it was messy. I didn’t like it.

Other students would be particularly distracting for Pegasus when he was in-person. “I would tend to go out in the hallway and do the tests because I was like these kids are too noisy. During the test, I heard a pen clicking.” More students also meant a pace that may not have suited the needs of the learner. Bootes expressed, “My father’s brain is like this too, but we don’t have to repeat stuff. In normal school, they have to drill the info into you by repeating it over and over.” Similarly, Vulpecula experienced “in math, I always finished like the things before everyone else. And then, I just doodled in my notebook, and then I kept getting in trouble for doodling in my notebook.” In contrast, Tucana shared:

> In sixth grade, like towards the middle of the school year, we were doing more and more stuff and it got kind of complex in English and writing on what we were doing. And sometimes, it took me longer than the teacher was teaching for me to understand…I’d be a little behind, but then she’d do lessons that were easier and that’s when I’d catch up.

The ability to review content was confirmed by all participants. Aquila highlighted, “I like it [virtual learning] a lot better because you can always go back to stuff.” Taurus appreciated that resources were accessible and “instead of waiting and try[ing] to find the classroom. I can just click on a lesson and actually do it.” Bootes agreed with the manageability of online

learning; “We work around it, so like I’ve done two lessons for tomorrow, today.” Columba concluded:

> It’s both easier but also more challenging for me because there are videos that I can watch and listen to for school. Listening is one of my main ways of learning and reading. And that’s basically a lot of online school, and that’s the main way I learn because then I can just do better.

Student Driven

In order to qualify for participation in this research, candidates needed to self-identify as being intrinsically motivated. As asynchronous virtual education is learner-centered, this characteristic is essential for success. The sentiments of intrinsic motivation transcended the preliminary requirements and was a shared lived experience among 14 participants. Pyxis did not provide insight into how he re-engages with schoolwork; however, he did explain how he “just wants to get back on” to a videogame after taking a break. Additionally, Pyxis substantiated that he typically cognitively disengages when “I had to get out of bed. It always happens. I’ll sit there and be like ‘Do I really need to get out of bed?’” In contrast, Aries summarized, “I wanna [*sic*] learn how to aim higher so like in the future with bigger goals to take like jobs and universities and stuff like that, I can *easily* [emphasized] go for it.” Likewise, Cassiopeia shared, “I really want to do nursing because my grandma was doing nursing… That’s why I’m trying to grade a year earlier if I could.”

Along with Aries, there were three other participants who had a drive for perfectionism. Bootes explained, “My brain likes to get things right on the first try. I use to be more of a perfectionist. I’m less of one now, but I still am a perfectionist.” Virgo validated, “When I get to

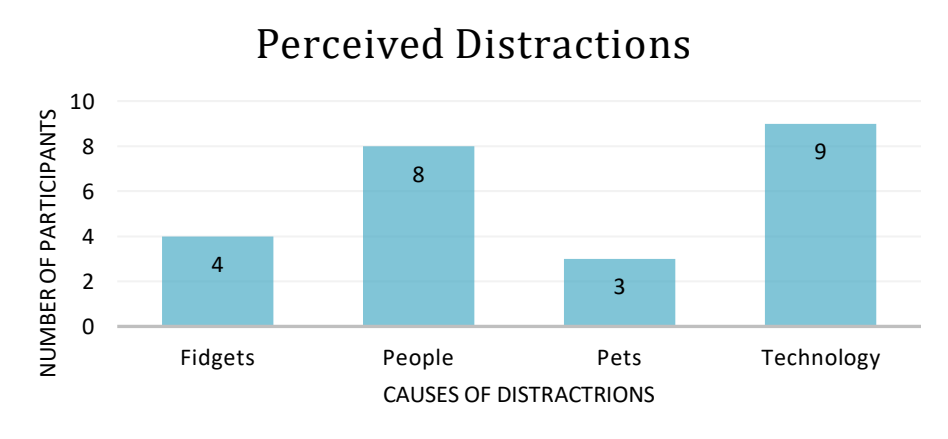
the interactive, if I don't get it completely right, I get mad at myself. So, I must get it right." Most comprehensively, Phoenix shared:

> I am a perfectionist…and my brain decided to be very uncooperative and thankfully I was able to get a[n] retake afterwards, but you could have said the sky was falling and that a meteor was coming right for my head…I guess I just feel like I compare myself to other kids and think that the kids were perfect in their learning—getting done—I know they weren't, but I thought for a minute and thought they were getting done. And, I remember that I use to go into this rut.

According to the participants, being motivated does not make one immune to distractions. Distractions were a shared lived experience of 14 participants (excluding Taurus). These perceived causes of distractions are illustrated in Table 2 below.

Figure 2

Perceived Distractions



Unsurprisingly, technology was the most cited type of distraction for these virtual middle school students because they are on the device already. Bootes explained, "When I have gmail—I'll be messaging my friend—and then I'll forget to close the chat, and it'll keep blinking." Lupus confirmed, "I just kind of picked up my phone to read a notification and then ended up watching

YouTube shorts for 10 minutes." Distractions caused by notifications and text messages were also identified by Aquila, Aries, Draco, Norma, Tucana, Virgo, and Vulpecula. Moreover, eight participants would get distracted by other people (specifically "loud siblings"). Five participants identified their "environment" as being distracting while three participants would get distracted by a pet. Fidgets were used by four participants, but sometimes these sensory toys could become a distraction. Columba explained:

> Fidget toys often weren't allowed at my in-person school. People would misuse them, and they'd be loud and distracting, but they're meant to be things that stimulate your brain other than what you're doing so that you can focus the best way you can. They're simple. They're simple concepts that you can just do whenever to help you focus.

Another perceived commonality among these virtual learning participants was their acute understanding of motivation time and adaptability. During the Thursday focus group, Bootes summarized, "From what I can tell, we've had a general agreement that we'll have like bursts of good moments and then we'll have other times. We'll have like some good moments, but mostly just like distracted." Along with Bootes, there were five participants who identified the morning as being the most productive or focused time of day. Although, Aries and Norma quipped continuing lessons at in the "late hours" such as "1-3am" when they felt motivated. Phoenix capitulated:

> I think I get pushed into that mode [of not focusing] if the day starts going along. I'll be looking at the clock, and I can see the minutes ticking by and I'm not exactly ticking with them… [A] fictious person has started this mental countdown.

Alternatively, four participants emphasized that focus is driven by mood. Aries stated, "It takes a lot to overload my learning mindset. It really depends on how my day started." Similarly,

Columba expressed, “I just have to start doing schoolwork at the right time when I’m in the right mood, so I can actually focus.” Phoenix admitted, “Sometimes at the end of the day, I can get a little short.” Lupus elaborated:

> It’s sometimes really how you feel. If you get up and be like, wake up bored already and don’t want to do [anything]—just wake up and kind of just don’t feel like doing school…especially on Monday. Especially Monday’s. No one likes Monday’s.

Another synergistic perception among the 14 participants was the acknowledgement of their own mental reengagement process; however, Draco analyzed, “I’m gonna [*sic*] sound weird here, but me personally, I don’t really have a strategy for it. I kinda [*sic*] just realize ‘Oh wait, I should be doing this. What am I doing?’” Similarly, Pegasus reflected, “I just decide to come back.” Conversely, Taurus shared his break strategy which is followed by him trying “to focus. I try to go back to where I left off.” Three other participants re-engage by finishing their task. Aquila explained, “[I will] try to do little doodles and whatnot, and then that kind of helps me get *back* into it.” Phoenix warned, “If your brain starts to daydream maybe giving yourself a minute…The catch is not to take too much time [on a break] because then your brain might want…go ahead and move onto something else.” Vulpecula concurred with both Aquila and Phoenix. On the one hand, she stated:

> If I get distracted drawing, I finish the drawing and then go back to it. Or, if I got distracted because my friend or family texted me, or a group chat that I’m in, mostly just read what they’re texting—maybe text back—and then try and get back to work… or like continue the break and not go back to work.

Cognitive Threshold Processing

The cognitive disengagement or overload phenomenon was a shared lived experience among all the participants. Eighty percent (12) of the participants were able to describe the overload phenomenon with detail. Aries and Bootes expressed knowing "exactly" how to explain the feeling of mental overload. Some sentiments were general statements while nine participants used specific (technology-focused) metaphoric language. Notably, participants presented various external and internal factors that impacted their cognitive threshold processing.

Four participants described their cognitive overload experience as a form of blank or nothingness. Columba shared, "No thoughts. There are none," and Draco analyzed, "There's no sound, first off. I don't know how there would be sound in it." Aquila and Phoenix addressed insufficient processing power by (respectively) stating, "Otherwise, my brain just stops comprehending anything," and "Disengagement sounds like brain activity has gone down. I'm not exactly thinking about having a clear mind anymore."

Nine participants interpreted cognitive disengagement using a metaphor with technology-associated language. Aries described her "mindset disconnecting," Aquila characterized the mind "unplugging from the situation," and Draco rendered, "sometimes the lesson doesn't click with me." Tucana explained:

> It's kind of when I'm out of the game. Yeah, I'm out of the game. I'm not really connected. It almost feels like I'm not listening to as much since I'm out of the game…So I got to get back in the game as quick as possible. Yeah, otherwise, it just spirals out of control.

The other five participants provided more direct technology analogies. Pegasus illustrated, "If I have like a little chip for my mouse that plugs into my iPad. If you disengage, then I would pull

it out, and the mouse turns off." Pyxis compared the phenomenon to disengaging from his "Xbox controller," which was accompanied by the gesture of holding a videogame controller then putting it on the desk. Columba and Phoenix depicted mental overload as the "equivalent of a laptop restarting." Phoenix elaborated that her brain restarts after "every new subject." Subsequently, Taurus portrayed, "I guess it's like something either breaking or something getting popped off. Like a train getting popped off the rails. Like a puzzle piece out—like a puzzle piece, and I [can't] make a puzzle."

For 11 participants, cognitive disengagement due to external factors were another commonality. Along with the previously mentioned distractions, environment and people were identified as influences on the overload phenomenon. Phoenix compared this to a balloon that has been inflated under pressure and "just slowly deflates." Because they sit by a window, Aquila and Pegasus indicated high ease of distractibility due to more movement or noise outside. Furthermore, Cassiopeia, Columba, Lupus, Norma, Taurus and Tucana's mental processing would be interrupted by siblings. Alternatively, "technology glitches" would disrupt Virgo and Vulpecula's focus.

According to participants, technology does not have to malfunction to negatively affect their cognitive threshold and processing. Four participants acknowledged that when lessons get "too hard," then they are more likely to "space out." Whereas, seven participants deemed "boredom" as the archnemesis of focus. Draco quipped, "I usually don't have a problem with focusing. But again, it's kind of the sheer boredom when you don't get something and going over it 10 or 20 times." Similarly, Tucana shared, "Cause [*sic*] I didn't like that class. It was boring. Sometimes I'd zone out. Like I said, I was kind of just bored." Although these are external factors, they can elicit internal responses. Columba explained:

> For example, [if] I were to be playing guitar or sketching or something, and I get bored—like I'm under stimulated—it depends on what mood I'm in. But sometimes, I'll play music or I'll take a little 10-minute break and read a chapter of one of my favorite books or stuff like that. Maybe I write a short little story from one of the thousands of ideas that pop into my brain at the randomest [*sic*] times of day.

Including Columba, there were 11 participants who cited confusion as disrupting cognitive processing. According to the participants, there were various components associated with confusion. Math (particularly word problems) confused Aries, Cassiopeia, and Lupus. Lupus said it "didn't make any sense." As a result of history concepts being "confusing" for Taurus, he described history as "my least favorite class." Additionally, poor delivery was detrimental for Phoenix's processing. She expressed, "Her [the teacher's] math lessons weren't comprehending with me. I could barely ever understand it. It was like I was always a half meter above water level." Moreover, vague instructions confused Virgo. She expounded:

> So, I opened up the lesson, and it was one page, and it was just a link. [I] clicked on the link, and it brought me to a PDF page—the test—and I looked at it, and I'm like, 'What is this? Huh? What?'

Moreover, seven participants described their emotional reactions as a result of being confused. Cassieopeia and Phoenix would get "upset," Bootes would "get freaked out," and Tucana would become "really emotional." Virgo concurred with Pegasus who shared, "I think I cried a few times in a day" but would feel better after "screaming into my pillow." Similarly, Aquila and Bootes would "squeeze a pillow" to "calm down."

Metacognition

All participants were not only able to thoroughly describe their shared lived experience of the cognitive threshold but also their metacognition or awareness of their thought process. Pyxis, Taurus, Tucana, and Vulpecula indicated that in the moment of cognitive disengagement they would "take a step back" as they recognized that their brain went "off topic." Some participants described inducing cognitive overload by ruminating on the task at-hand. Columba, Lupus, and Phoenix summarized this as "dread." Supporting Aquila's perspective during the Thursday focus group, Columba explicated, "Often times, it's just a long lesson that I was *really* [emphasized] dreading doing. So, it's kinda [*sic*] of that dread within me that makes me not *want* [emphasized] to focus. It makes me not want to have to do it."

On the other hand, five participants perceived a lengthy agenda as daunting. All participants concurred that perception of too much work would trigger them to zone out. Although, the specific lesson structure was subjective and not uniformly agreed upon. For Aquila, "a lesson that was 24 pages long" would make her not "feel like it. I'll do it if I *have* to." Cassiopeia explained that her teacher "expects us to write a lot of notes, and it's like really? Why do we need to watch this and write a *bunch* [emphasized] of notes? [In] Global studies you have to write a *lot* [emphasized]." During the Friday focus group, Draco elaborated by typing:

> Usually too much stuff in one lesson. I'd be fine with longer units if they focused more on individual subjects. If there's too much stuff—probably all paragraphs. Yeah, I don't really have a good stance on this sense. I kinda [*sic*] just ignore the videos…I'm sorry, I do. If i [*sic*] do watch the videos, I'll speed it up to 1.5x or 2x.

Five participants also highlighted that the perception of an overwhelming lesson can change depending on their personal circumstances. Bootes shared, "I've been sick recently, and I still kinda [*sic*] am. I've been having—my brain can't focus lately until like—I'll have little

sudden bursts of juice. Like today, [I got] one lesson done in two hours." Phoenix reluctantly indicated that sometimes she does not feel "up to it," but "I still do it—tying to the laziness—cause [*sic*] I guess I'm human, you know? I mean I'd love to get through an entire lesson with laser focus. Superwoman focus." Furthermore, Bootes and Phoenix addressed the time of day. Bootes relayed, "It's kind of like my brain slows down because it used it's juice in the morning." Phoenix noted that as the day goes on "you start to have this sense of disappointment."

The other four participants' notions aligned with Phoenix's sentiments as they would metacognitively reflect on the consequences of their actions. Bootes explained, "Basically inside my head, [I think] 'Oh shoot, I need to get these lessons done before tomorrow because we're going to be gone tomorrow.' And so, I basically blasted through a bunch of them." For Columba, "Once I start acknowledging the fact that the sooner I do it, the sooner it's done. Once I start fully realizing that, then I start focusing better." Likewise, Pegasus and Lupus reflected on this ripple effect. Lupus examined:

> I just kind of thought about how long it would take me to do my test. I said, yeah, I better just complete my test because if I don't, I'm going to sit here on my phone for the next two hours and then be completely behind and then not really play any games today.

Another commonality among participants was the shared lived experience of the eye glazing phenomenon. Over thirty percent of these virtual middle school students described situations in which they were metacognitively processing thoughts other than comprehending the reading. Norma elaborated:

> I start to just read it and not actually remember it or think about it and just scan with my eyes. And then, I'm done with the paragraph, and I forgot to actually read it and don't remember anything really. You know you're scanning, but you're not processing—either

> thinking about something in my surroundings or something that I have to do later that day or in the week.

Aries corroborated Norma's sentiments by stating, "…when you know when you're reading it, but you don't understand a word you're reading. Like it's not hard or difficult, like your brain just *stops* [emphasized]." Moreover, Columba explained:

> The best way to describe it would be I'm reading a sentence in a paragraph or I'm rewriting a sentence for something, and I just don't comprehend it. Like, I read the words, and I know what the words are. I could probably read them aloud to you from memory, but I just don't comprehend them.

There was not perceived uniformity on re-engagement strategies. For Bootes, Columba, and Lupus an auditory cue would cause them to refocus; Lupus indicated that talking would "reset whatever you're doing." In contrast Norma and Virgo, their awareness of being mentally disconnected combined with the visual cue of the "end of the paragraph" can also be sufficient. Virgo summarized the frequent eye glazing reading phenomenon:

> In general, I'm reading the lessons, and I'm still like—half my brain is reading it, and the other half is thinking about anything else. And then, when I hit a point where I stop, where I just get distracted from being distracted, then I go back and I'm like 'Oh, I just read through this, but I don't remember what I just read'...Usually, if I hear a noise or my phone makes a noise or I get to the end of a paragraph, I'm not thinking about it, but my brain is—still I wouldn't say reading. I follow my eyes, like across the page when I read, so it just does that. And then when I get to the end, my brain is like 'Okay, you're done. Come back.'

The Rogue Brain

Uniformly, all participants provided evidence that they share the lived experience of cognitive disengagement. During the investigation, this phenomenon of "the rogue brain" surfaced as many of the participants cited instances in which their brain's action conflicted with their current internal desire. This sub-theme was born from the observation that many of the participants referred to and interacted with their brain as an external factor. Along with Virgo's sentiments on eye glazing, Phoenix shared, "My brain does try to find creative ways to exit the scene of schoolwork," and "Sometimes, it's like you've made this commitment to get things done and now it's late, and your brain is like *I'm over it* [emphasized]. I don't know this, but it's like just going into average teenager [mode]." Furthermore, Phoenix expressed:

> Sometimes, I have to admit that there are times when your brain—although that it knows that it needs to focus—it like never actually focuses, or if it knows that it has the ability to focus. Then, if it's this way or that way. It can focus, but sometimes it's kind of like *I know I can focus but yeah* [emphasized]... it's more that you have the ability to focus. but your brain half-way chooses not to because you feel like you can focus but for some song is still stuck in your head, or you have allowed it to stay in your head or something.

Aries explained that the rogue brain experience did not have to do with "if you're quote unquote dumb or quote unquote smart. Stuff like that does matter at all." She described, "I still remember what I learned at school, but it's a different type of mindset. Maybe when my learning mindset slightly goes off. Maybe when I'm thinking about other things." Columba provided the logic, "Your mind is not stimulated, and it just goes to do other stuff."

Moreover, three participants described scenarios in which their thinking was so obstinate to the task at hand, that they had to give into the activity to satiate their brain. Aquila explained,

"My brain's weird like that, so if I just start it, [I need to] keep going, until I finish it." Columba reflected:

> Say I'm doing honors geometry, but my brain won't stop thinking about life science. I stop doing honors geometry. I remember what page I was on so that I don't lose my progress. But, I stop doing honors geometry, and then I go do life science because I know that doing that would just be more efficient for me and my brain at that point in time.

Additionally, Aries and Bootes described redirecting their brains as Aries would ask "No, what am I doing? I'm doing school, what am I thinking about?" while Bootes would self-talk "oh stop it" when his mind goes blank. Bootes accompanied his expression with a gesture of playing whack-a-mole. Norma provided the following text in the focus group chatpod, "I don't think any teacher could make me engaged, my mind wanders everywhere…all the time." Most notably, Columba explained:

> While reading those [articles] I was kind of thinking of how I would phrase things in my essay, but it was actually [the] writing my essay where those things that I had thought of for me, things that I would use in the essay, [but] my brain pulled the blank. That happens a lot too, unfortunately. I have an awesome brain, and I know that, but sometimes, my brain just doesn't brain.

Along with having a blank brain, nine participants explicitly described cognitive disengagement as spacing or zoning out. Pyxis shared, "Well, like at least once in a while I'll like zone out." Columba acknowledged, "Yeah, spacing out is a good way to describe it. No thoughts. There are none. Two seconds ago, my brain was running fast as a freight train and now it's just not." Likewise, Pegasus was able to provide specific insight:

> Well, as I'm spaced out, I usually picture [in] my head, and I'm usually hitting it with my dog or being a NASCAR driver or flying like an airplane. Because, sometime when I grow up, I might think about being a pilot.

For Virgo, the lesson videos will cause her to "space out," or when she's reading a lesson, "I'm still like, half my brain is reading it, and the other half is thinking about anything else." Taurus described his experience as:

> When I'm like zoning out or something, everything kind of gets blurry, I guess, and I don't really think about that role or something. But, I'm like nope. Try to do something else, so then I can refresh. So then, I won't zone out.

Similar to Taurus, there were eight other participants who were able to metacognitively identify when their brain was not focusing. Norma had to "realize" and Draco "eventually…kind of just notice[d]" that they were no longer thinking about the task at hand. Virgo would review, "Oh yeah, I was reading that."

The shared rogue brain lived experience was also described by participants as occurring when there was a disconnect in understanding. Draco referred to these instances when the lesson "just doesn't click with me." Bootes extrapolated, "Often times, I'll feel I'm not understanding the *subject* [emphasized], I can't find the *answer* [emphasized] to it, I'm not *getting it* [emphasized], sometimes my *mom* [emphasized] explains it wrong, or she says the wrong thing…that doesn't help my brain." Phoenix reflected:

> I feel like the main thing is that I just wasn't getting it. I just wasn't understanding the way they were saying it—maybe the wording—maybe that there were so many sentences all to immerse in my mind, and I couldn't handle it…Now that I think about it, I think my biggest obstacle in my learning could be me.

Virtual Learning Strategies

The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. Online education is student-centered at its core due to the increased asynchronous learning time. In the Wednesday focus group, Phoenix described virtual learning as "matter[ing] more if you put your all into it." There was a homologous theme of virtual learning strategies among all 15 participants. Their collective perceptions included comprehension of lesson structure and identification of learning opportunities.

The parent company Orion creates the curriculum for Rigel virtual school. Over 80 percent of participants not only acknowledged but depend upon the consistency of lesson structures (regardless of the course). For example, Columba highlighted the "definitions" at the beginning of a lesson. Lupus and Taurus also indicated that the "front" or "first" page (respectively) contained important information. Draco quipped, "I don't think I've ever come across unimportant information. I'm trying to remember if there's any information that wasn't noteworthy, but I can't think of anything."

Universal consensus was not reached for describing the ideal lesson; however, the collection of the participants' perspectives did highlight their ability to scrutinize lesson structure. The majority of participants had a negative perception of "super long lessons" (Tucana) that have "just like a *lot* of information" (Aquila) with "too much block text" (Phoenix) and many "pages of reading" with few "check-ins" (Bootes), "splitting things up without any explanation" (Draco), or just too "vague" (Virgo). Additionally, there was a distinctive division on the perceived benefits of multimedia learning. Eleven out of 13 participants shared Norma's viewpoint of enjoying "mostly visual text and lots of audio. I prefer videos and text, but text is

more overwhelming." In contrast, Aries pontificated, "I don't like reading short articles. Like if you're gonna [*sic*] make me read something, like recommend a book or something. I don't like reading short, little articles."

It was admirable that nine of the participants embraced vulnerability by acknowledging their learning opportunities. The shared perception that "there is a lot of reading and writing" in virtual learning was epitomized by Pegasus. He elucidated, "My weakness is reading." Aries confirmed that she prefers "the basic number questions" such as "match the definitions," and Virgo capitulated, "I don't do well with learning what it's *like* [emphasized] or what it's *connected to* [emphasized]. I want to know what it is." Moreover, four other participants expressed how they benefitted from assistance with the skill of summarizing. Along with summarizing, Phoenix expounded that it can be difficult to identify examples of "important information."

Augmenting Modalities with Multimedia Approaches

The multimedia infused nature of virtual education makes this style of learning enticing to intrinsically motivated students. All 15 participants expressed a collective firsthand encounter with regards to augmenting modalities. Similar to lesson structure, there was not a unified agreement on learning preference; however, 100 percent of participants shared their opinion about auditory. In the Thursday focus group, Bootes began by expounding, "I learn in a couple ways, but I mostly learn—I'm thinking—audio. I think [by] listening." He also teased, "I'm alone?!" when the four members self-identified as "visual learners."

During the individual interview, Bootes also shared that he has "a lot of sensory things" and described how weekly he will "grab one of these clear buckets, and I'll put some fidgets in it." Likewise, Columba utilized homemade fidgets that are "simple concepts that you can just do

whenever to help you focus." In both the individual interview and Wednesday focus group, Vulpecula was observed constantly manipulating a squishy sensory item. In contrast, Virgo refrained from using manipulatives as "there's a lot of little things in my room that I can get distracted by." Alternatively, Lupus, Pyxis, and Tucana promoted kinesthetic learning. Lupus made solar system brownies while Tucana designed bookmarks and Pyxis created a magnet from two batteries, wire, and a paperclip.

According to participants managing the auditory channel can help or inhibit focus. For example, Aquila highlighted how she always has music "playing in the background" which will help her read lessons. Similarly, Columba explained:

> The best things that help me focus are kind of just like lo fi music which is basically just like kind of hip hop but no lyrics at all or sometimes classical music depending on what mood I'm in…Music with no lyrics playing can be nice because then I don't need a fidget as much. I don't need something else to stimulate my brain when I'm taking notes and stuff, or I'm reading about a lesson to help me retain the information while reading the lesson. It's nice to have another small thing stimulating my brain.

On the other hand, eight participants shared that overloading the auditory channel with sound can push them into cognitive disengagement. Aries expressed, "My family is so loud, they keep arguing—my sisters—I cannot answer in peace." Cassiopeia reflected similar sentiments when her brother makes "loud noises, or the TV is so loud [that] it bothers me. It's like loud noise just bothers me." Excessive technology volume was unanimously discussed in the Wednesday focus group as each of the four participants provided specific instances in which their "headphones" (Phoenix), "TV" (Tucana and Vulpecula), or "phone" (Lupus) volume was turned up too loud. Lupus elaborated "…since the video you're watching is like extremely quiet.

Then, you go to watch another video, and it starts blasting and blowing down your house and the whole neighborhood can hear you."

According to four participants, overwhelming multiple channels puts them in a self-preserving response. Over the summer Aquila experienced a soccer event in a dome that was "…*so* [emphasized] loud. I sat on the ground for three hours because there were so many people. It was absolutely insane, but that was like the most information I had one day in my entire life." Additionally, Phoenix shared:

> I went out there and my dad was using a high compression air hose to get the dry leaves out of the garage, and all of a sudden, it just felt like something out of—it just felt like it was very overwhelming. Like, I don't want to say fight-or-flight response, but it's more of—it definitely makes you want to get out of there pretty soon because of how loud it is.

Tucana corroborated, "And at the times where the kids [his siblings] are too loud, and I just get overwhelmed. I don't want to be with anyone." Moreover, Pegasus explained when he gets "stressed out. So, I just go like okay, too much stress. I'm going to black out now… So how I get back from spacing out is either my mom talking to me, or I just decide to come back."

Along with Pegasus, nine other participants will mentally disconnect when their channels are stunned. Bootes described his experience:

> I also want to note that one more thing. when I do the *forced space out* [emphasized] or sometimes it's just me spacing out real easily. Like sometimes, I'll be staring at something and then I'll just space out at it. I can still listen to things and respond to things. And it's not until I like move my head to look at something or something loud catches my attention that I can look away.

Loud noises, calling one's name, or signaling a change in activity were shared common examples of how participants' focus was re-engaged. Tucana also added that "the person in front of me would tap me" along with saying his name.

According to six participants, the auditory channel can also enhance perceived comprehension. Reading aloud was beneficial for Cassiopeia, Pegasus, and Taurus. When learning with her Learning Coach, Aries explained, "she makes sure I heard it. Then, she makes me repeat it. Then she tried to make me teach her again." In a similar fashion, Columba's Learning Coach will leverage the auditory channel. Columba expressed:

> I understand it better because I heard someone say it instead of reading it…if me reading it aloud didn't do anything or me, then she would read it aloud, try to resummarize [*sic*] it in a different way, or simplify it even more.

Bootes validated Columba's experience with an equivalent example of how his mom helps. He shared:

> So, my mom will keep explaining it in different ways and eventually she'll explain it one way, and it'll be like [head explosion gesture]. And I'll immediately be like, 'Oh! *That's* how it works.'…until my mom said something, then it all clicked in my head. I then need—my mom will *say* it in a different way, and then it like completely unclicks in my head like someone just turned a key.

Effective Signaling for Virtual Learning

One hundred percent of participants shared the lived experience of signaling. There was full consensus on the perceived effectiveness of signaling in virtual learning; although, the participants did not agree on which type of signaling was superior. Signals were acknowledged

in three specific manners: incorporated in resources, utilized by teachers or learning coaches, and implemented by participants.

All participants were able to identify signals used in the resources in the lessons or those created by teachers. For instance, five participants addressed the highlighted "keywords" while four participants addressed "context clues" as being helpful. Taurus defined context clues as "guesses that you get when you read through a story or a paragraph, and basically, you can use context clues to find out what a word means without looking it up or using a dictionary." Several participants appreciated the when "eye catching" (Aries) signals streamlined identifying important information. Bootes explained, "If it's blue in the lesson like where you hover your mouse over it, and it'll give you the definitions, write that down." Cassiopeia appreciated then multimedia hyperlinked definitions because then she did not need to "look up what the meaning of the underlined words [are] in your glossary." Lupus concurred because if important information is not bolded then, "you have to search out for it."

All participants easily perceived signaled importance in resources based on other visual cues. For Tucana, signals were "obvious," whereas Aquila and Phoenix followed the "title." If a "whole paragraph" (Bootes) or an "entire page" (Draco) was dedicated to one topic, participants perceived this as an indication to "write down things related to" (Phoenix) the "main idea" (Taurus). On the other hand, Pyxis and Columba detected the big picture concepts if it "seems important" or "going off of tone" respectively. Phoenix also elaborated on using teacher resources as a signal:

> I like it when (well) I realized that my US history is the one that I can understand the most. It has a textbook, and it has a pretty comprehensive study guide. I guess I *trust*

> [emphasized]. I *trust* [emphasized] in it. I trust that it's not going to leave any information out.

There was solidarity among participants that—as Virgo summarized—some signals were "more noticeable than others." In the questionnaire, participants were asked to compare common forms of signaling. Highlighting was favored among eight participants. Draco shared, "For me, highlighting was the most obvious and bolding was the least obvious. With the bolding, I straight up guessed [on the questionnaire] because I could not tell the difference." Contrary to not having "really seen these used," he acknowledged that "bolding or highlighting keywords helps me"; however, Draco also distinguished that "bolding doesn't really work in image form, but it works well in text form."

Additionally, the context in which the signals were utilized were perceived as influential on which type of signaling was most effective. Aries reflected, "Highlighting on images would stick out much more than if one used it on text." Conversely, Bootes stated, "Bolding works *way better* in text." Norma endorsed both sentiments as she expressed, "I can see what is important if words are highlighted, mentioned a lot, or the main topic of a lesson…Bolding can be helpful for text but difficult for an image." Furthermore, Lupus promoted bolding as having "purpose in the text. So, it still stands out but not as much as the image… But, it kind of depends because in the text, you can't really do blurring either."

Five other participants shared Lupus's perception on images. Both Bootes and Virgo preferred "blurring" with images. Moreover, Columba and Cassiopeia joined the previous three participants in the appreciation of icons with images. Tucana quipped, "[Signaling is] less effective with the writing because it's the picture for our childish brains. Pictures are still very good, so you know. Picture. Go pictures!"

There were three other multimedia strategies that were universally celebrated among all participants: assessment driven, explicit directions, and repetition. Participants cited these shared lived experiences in the context of resources as well as by others (especially teachers and their learning coaches). Aquila proclaimed, "*That's* [emphasized] one of the reasons why I look at the quick check *beforehand* [emphasized] like I really need to know what I mainly focus on. That's why I look at the quick check beforehand because it helps me like *know* [emphasized]." Draco elaborated, "Whatever's in the quick check is probably important." In addition, Virgo explained, "Well, if I'm stuck and confused on a lesson and I'm like a quarter or half of the way through, I skip to the quick check and see what I already know."

Ten participants valued explicit directions as an effective form of verbal signaling. Similar to using the assessment itself as a guide, participants shared Cassiopeia's sentiment that it is helpful "when teachers tell us it's important and on the test." Aries and Tucana indicated verbal cue phrases like "do not forget to do this" or "this is important." Additionally, Aries said that it's helpful when her "social studies teacher lists each step of the assignment, so it's really clear what I need to do." Virgo corroborated Aries experience as sharing "links" has been good guidance. On the other hand, Pegasus, Phoenix, and Taurus recognized their moms for "encouraging to write down only the most important information" and when directing "what to write down."

Repetition was a shared dichotomy among ten participants. On the one hand, seven participants recommended "if they keep saying it" (Norma) or "it's repeated multiple times" (Vulpecula), then "write it down" (Phoenix). On the other hand, some participants perceived repetition as leading to cognitive overload. Along with many pages with repetitious information, Cassiopeia expressed:

> One time I feel asleep during my last week in LiveLesson because it was really boring. I didn't remember any of it, and I feel asleep. The whole LiveLesson. The teacher had to keep repeating herself because people that wasn't listening. LiveLesson got really boring.

Along with Cassiopeia, seven other participants commented on disconnecting when the lesson information would get "repetitive."

All 15 participants shared a common lived experience of recognizing and promoting the use of signaling. The majority of participants also leverage signaling in their own notes. Question #2 of the questionnaire prompted students to describe how they would help a classmate complete a lesson. Aries, Bootes, and Lupus indicated that they would help their fictitious classmate identify the important information through the use of signals. Bootes would "help them under stand [*sic*] that the underlined words are important information," while Lupus would "tell them to look at the highlighted information." Equivalently, five participants were guided by adults using visual cues. Pegasus shared, "In her slide pages, like we use Nearpod all the time for Language [Arts]. There would be, like, this little pencil that indicates that we need to note something down." Furthermore, Tucana's dad will help him with lessons. "He helps me usually by sometimes he'll give you hints. Like if we're online, he'll move the cursor towards one." Taurus used technology pointing as cue for himself. "Well, I guess before zoning out, I like to use my cursor and make it a little bit blue, like I know where I left off."

For the other nine participants, color played an important role for their personal use of signaling. Aquila, Draco, Norma, Phoenix, and Pegasus utilize different colors in their notes for quick reference. Aquila exclaimed, "I color code *everything* [emphasized] depending on the class, but it kind of goes in order of the rainbow." In the Thursday focus group, she expounded:

> I'm completely over-organized and color-code absolutely everything when I feel like it. And, I'll add—I'll do like *those* [emphasized; signaling examples] like the icons or stars, and then I'll end up making complete drawing because I get distracted. But otherwise, I use like all of those."

Cassiopeia, Columba, Norma, and Vulpecula additionally built connections in their own notes through the use of icons, arrows, images, and doodles. Columba explained, "I also like arrows and stuff because then you can connect something from like one side of the page all the way over to the other side of the page."

Outlier Data and Findings

The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. The central research question and three sub-questions focused on capturing the lived experiences of the 15 participants during cognitive overload and the use of signaling. There were two resounding themes that emerged as constituted outliers as they do not directly respond to research. All participants explicitly identified the utilization of breaks along with specific strategies to set themselves up for success during their virtual learning experiences.

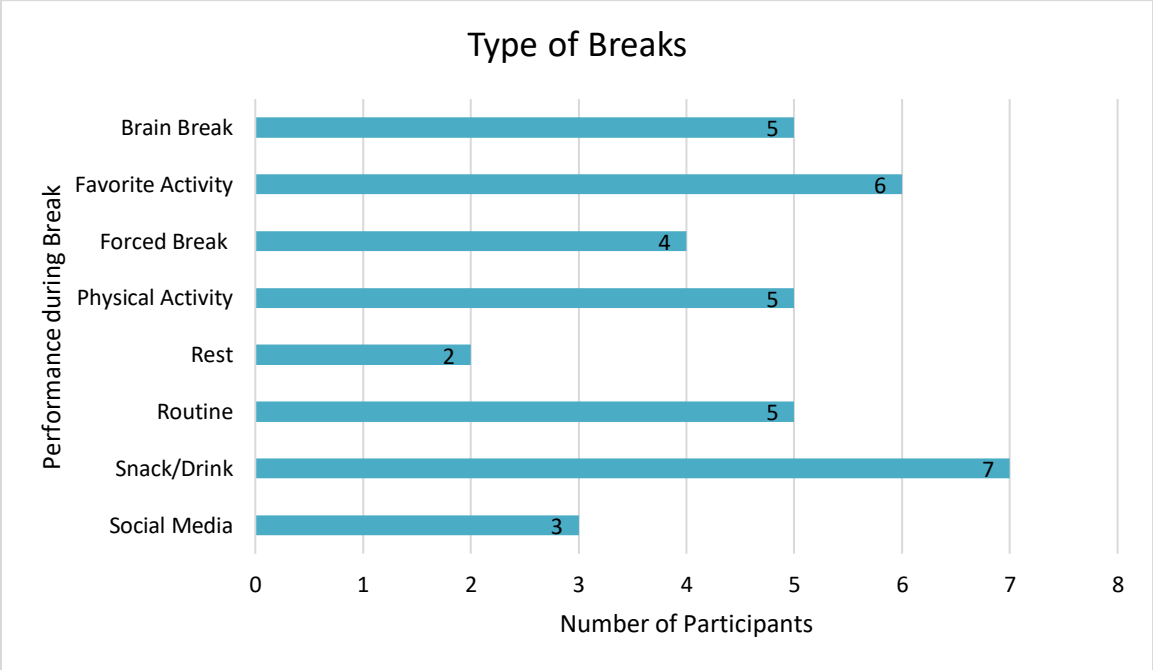
Breaks

All 15 participants had a shared lived experience of utilizing breaks. Although Aries claimed, "I'm not a break person. I wanna [*sic*] get this all done," she identified taking a break as a commonly employed strategy in response to cognitive overload. Questions regarding breaks emerged naturally in conversations and were not directly built into the research questions. The duration and type of break varied on the participant as displayed in the Figure 3 below. Consistently, all 15 participants would change their location or setting during a break. Six

participants (Aquila, Aries, Norma, Pegasus, Taurus, and Tucana) typically venture outside in some capacity. Aquila said, “If I star looking outside, I start thinking about outside, and then I wanna [*sic*] *be* [emphasized] outside. So then like, either just like wanna [*sic*] go on a walk or something or take a little break.” Likewise, Aries enjoyed, “a small walk outside in my backyard. Just like smell fresh air, ya [*sic*] know?”

Figure 3

Type of Breaks



There were five participants that explicitly cited taking brain breaks. Draco acknowledged that while he grabs a snack or “just something to munch on” he “wouldn’t really consider that like a big brain break.” In contrast, Aquila uses a brain break to “calm myself down.” Both Bootes and Lupus will switch to “a different lesson and come back later,” but Lupus did not explicitly use the term “brain break” and in fact expressed that he would not “necessarily take a break.” Tucana provided the most detail:

> I've seen my teacher do this before. They put in brain breaks, and they give us a joke or something like that or a quick time to grab some food and eat quick. Back away from the scene and get away from it. Take a break or do something fun so my brain resets. Then, before it's too much fun, go back.

Furthermore, Columba shared that she completed the questionnaire in multiple settings because "I prefer to take little brain breaks when doing something that takes a lot of focus so that my mind doesn't drift. In this case, my brain break was messaging with a friend."

Cassiopeia, Columba, Lupus, Pegasus, Taurus, and Virgo will do their favorite activity for a break. This ranged from watching their favorite show, reading a book, or socializing with others. Conversely, forced breaks were reasons that participants had to interrupt their virtual learning for a different activity. For Aquila, Cassiopeia, and Draco this was due to extra-curricular sports. For Pegasus, this was due to volunteering.

Physical activity was the purpose of a break for Aquila, Aries, Bootes, Norma, and Pegasus. Walking was the top choice. Along with the mid-day break for yoga, Norma will "just stretch." Bootes eagerly shared, "sometimes, we like to have dance parties. Like a 3-minute dance party, and then get back to work. We'll play 'It's Raining Tacos,' dance a bunch, then get back. To get the blood flowing." On the other hand, Pegasus will play with his dog.

Bootes and Taurus were the only participants to indicate breaks in the form of rest. Bootes's mom will direct him to "go take a nap" if he is tired and having difficulty focusing. Taurus explained:

> Sometimes when I need a break because my mind is like zoning out, and it's kind of hard to understand, I read my book or blink or something. Because, usually when that happens, I got to try to focus on something else, and then after that I go back.

He also shared that “resting my head” means “I don’t always put my head down” but can mean “I try to close my eyes and then try to focus.”

For five participants, breaks are routinely scheduled. On the one hand, Norma and Pegasus take a break at approximately the same time each school day. Alternatively, Pyxis, Virgo, and Vulpecula will take a break as a reward after completing a specified number of lessons. Vulpecula explained, “Mostly after one lesson, I take at least a ten-minute break.”

Meeting physical needs to promote mental processing was another main objective for breaks. Pyxis shared, “Well, I first go to the bathroom, and I usually get a drink or something to eat.” Six other participants (like Cassiopeia and Virgo) identified a “snack” and “water.” Moreover, Bootes expressed that focusing can be challenging when physical needs are not met:

> When I’m sick, when I’m tired, when I haven’t had enough protein. Like this morning, I had buttered toast for breakfast, and then my mom—I couldn’t focus—and my mom went and made me a peanut butter toast. And I ate that, so I could focus.

Three participants acknowledged using their phone during their break. For Draco, he expressed that he would “get distracted and start scrolling on social media.” Lupus and Virgo both shared that they would check their phones to “read a notification” or “see if there’s anything urgent.” This would lead to them watching videos. Although, Aries did provide cognitive disengagement examples of “thinking about video games and the latest update, social media, and stuff like that.”

There was not consensus among the participants for when they returned from the break. Several participants during the Wednesday focus group agreed that the desire to return can be a challenge. Vulpecula shared, “Yeah, I also agree…with [Phoenix] where you try but take more

than what you plan for a break. Where you don't want to go back to school, and you get to avoid it." Following-up, Aquila acknowledged:

> Yeah, that's like when sometimes, I can get distracted cause, I'm usually like by a window, and I usually get distracted by like literally the smallest—if I see like a pretty leaf, I will like go search outside and *find it* [emphasized]. I don't really care what I'm in the middle of doing, I see a pretty leaf, I *want it* [emphasized]. Otherwise, my brain just stops comprehending anything, and then I'll try to reread something over and over again, but my brain still won't comprehend it. So, then I just can't do anything. So then, I have to find something else to do until my brain actually starts focusing on stuff.

Set Up for Success

The second outlier confirmed by all 15 participants was their shared lived experience of being set up for success. While self-identifying as intrinsically motivated was a criterion for participation, all 15 students shared a pre-emptive approach to learning. Setting oneself up for success is an outlier as it does not fulfill the purpose of this transcendental phenomenological study which aimed to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. Participants did not address signaling under this outlier nor did they discuss combating cognitive disengagement because preparation for learning is pre-emptive. Aquila explained, "It's basically like how I initially get into a lesson." Columba elaborated:

> Similar to [Aquila], because for me if I'm not focusing on a particular lesson, it's because—I have this process where before I start any schoolwork, I plan the assignments I'm gonna [*sic*] do. Like if I'm going to be working ahead or if I'm tired and feel like slacking off a bit.

For five participants, being set up for success meant satisfaction and having your physical needs met before work. Tucana expressed, “We eat first. Well, we wake up, watch like a tiny bit of [a] show, then we go eat, then we pretty much get right into school after that.” Additionally, Similarly, Bootes highlighted:

> If I take my average day, it would be I wake up, I got to the bathroom, I play some videogames… it gives me a bit of a break in the morning. That way, I can get all my *I-wanna-do-fun-stuff* [*sic*] out first and then, I get those later in the day [with] me and my friends.

Cassiopeia, Draco, and Pyxis concurred that “going to the bathroom,” grabbing “a snack,” and getting “something to drink,” are ways they prepare before starting their schoolwork.

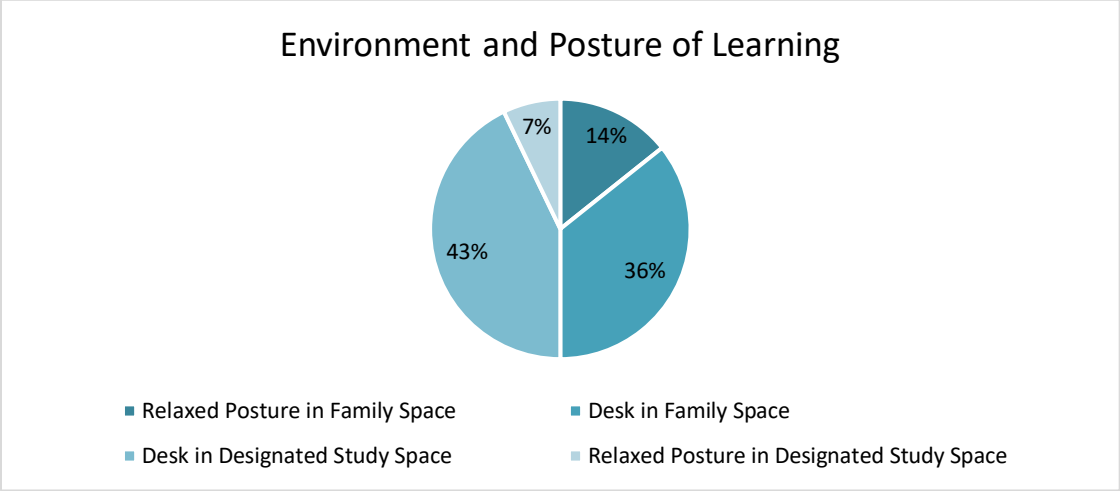
participants addressed the influence of the environment. Aries identified that she needs “a small little space for myself, you know? Just me, and like doing my work.” Bootes, Pegasus, Pyxis, and Vulpecula have designated areas for their learning. Bootes shared, “I take my keyboard and my mousepad and wrist rests I have, out to the shop.” Pegasus showcased his “school room” that had ample whiteboards, filing cabinets, and a large desk space. If sibling get too loud, Cassiopeia, Columba, Norma, and Tucana will someplace quieter. Norma explained when “the other kids come home” she knows “to move to my room, so I can finish the lesson.” Pyxis goes to a quiet study area “in the basement.” For Aquila, a specific location is less important:

> I have to be by a window. I usually have a Squishmallow or pillow or something like that by me or like a hoodie or *something* [emphasized] comfy…and then I remember that Spotify existed, so I then turn music on and finally get *slightly* [emphasized woken up.

Hugging a “Squishmallow” to “calm down” was also a success strategy shared by Bootes. Twelve out of the 14 participants who completed the survey, selected their typical school environment. This is illustrated in Figure 4 below. Additionally, all 14 participants completed the survey on their “school computer.”

Figure 4

Environment and Posture of Learning



According to the participants, posture was also an influential component when preparing for learning. Along with certain “environments” making situations difficult to focus, Virgo expounded:

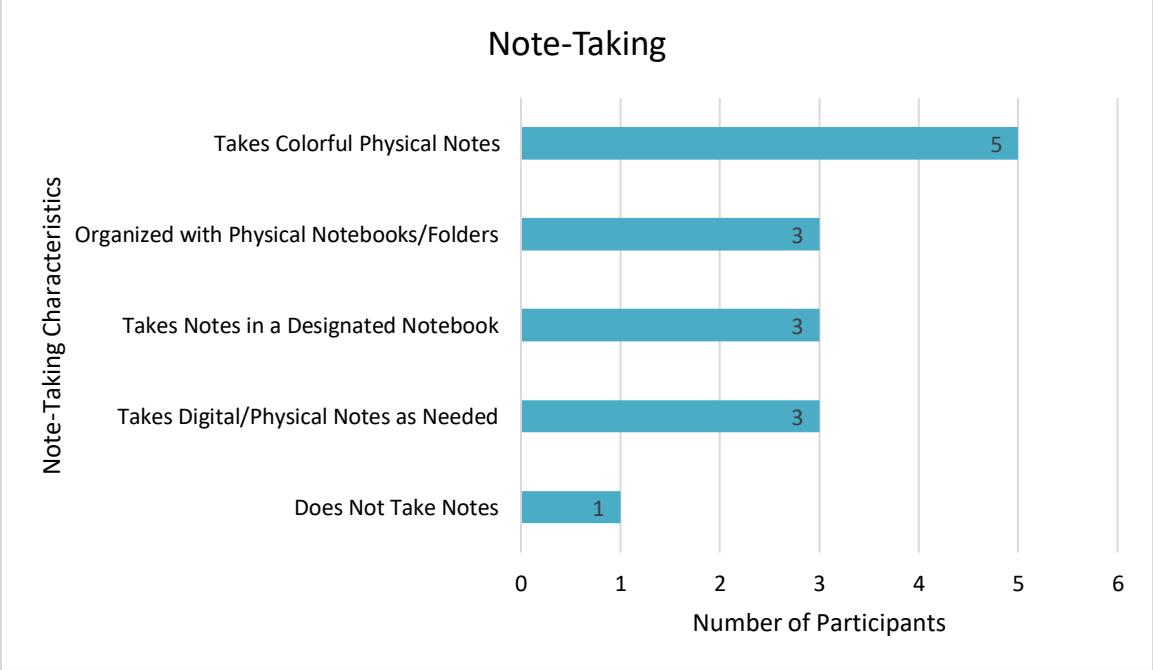
> I have a desk at both my houses, but at my dad’s my desk is a little smaller, so I can’t fit both laptops plus everything else I use on it. I usually sit on my beanbag. I have behind me. And sometimes I’m just in a position, and it’s like I’m tired, and I just—then I get distracted…But also, if I’m in a weird position and the computer is either on my lap or on my chest, it’s to be like I’m either looking way up or way down, and it kind of starts to get uncomfortable, and then I can’t pay attention as well because I’m trying to more around.

She concluded by mimicking sleeping against the wall. Tucana shared these sentiments as he remarked on the researcher's chair, "I see a really nice gamer chair. I have one that's a lot like that." In the Friday focus group, Aries expressed that she needs to "get in good posture" by "sitting up straight" to start learning. Draco quipped, "You just made me fix my poster lol."

Note-taking was another topic of discussion that did not directly answer the research questions; however, organization and utilizing resources were shared ways of setting themselves up for success for nine participants. Despite learning virtually, taking physical notes were favored by the majority of participants as illustrated in Figure 5 below.

Figure 5

Note-Taking



Important information was recorded in some capacity by 14 participants. Although, Draco explained that he completes digital notes because they are required:

> [Math] it's probably my least favorite because I'm being *graded* [emphasized] on my notes. I have to actually sit down and make my notes look nice. When I typically take notes, I just like—see, I should probably specify—I don't take notes often.

Besides Draco, Lupus and Vulpecula were the only participants to utilize digital notes such as the "whiteboard app" for completing math equations. Lupus also explained that he only takes notes as needed because "I have a second monitor. Here, I would have my quiz on my main screen, then my lesson on my second screen…sometimes I don't really remember the information, is just have it on the one screen." Moreover, Vulpecula refers back to the lesson and will "quickly read all the text till I find the part" that she needs.

Along with a dedicated school room, Pegasus was one of three participants who has an organization system of folders and notebooks. Columba expressed, "I didn't fill out my notebooks from last year, so I'm just using the same notebooks until I need to get new ones." Writing information down helps Aquila be set up for success because "or else I'll forget it." Similarly, Taurus explained that writing down important information from LiveLesson helps him "know what's happening, and then I can review them." Norma indicated, "During a lesson, if I think I'm going to forget it or that I'll probably need to look back on it if I forget, then I'll have it written down."

Research Question Responses

The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. In this investigation, there was one central research question and three sub-questions. The 15 volunteer participants provided their perspective and experiences for a variety of questions from an individual interviews, a questionnaire, and a focus group. The association

of interviewing questions to research questions can be found in Appendix K. Saturation resulted in three themes and six subthemes that directly answer the central research question and three sub-questions. The alignment is illustrated in Table 6 below:

Table 6

Alignment Between Themes and Research Questions

Theme	Research Question
Student Empowerment through Virtual Learning	CRQ
Cognitive Threshold Processing	CRQ
Virtual Learning Strategies	CRQ
Subthemes	**Research Question**
Freedom to Learn	SQ2, SQ3
Student Driven	SQ2, SQ3
Metacognition	SQ1
The Rogue Brain	SQ1
Augmenting Modalities with Multimedia Approaches	SQ2
Effective Signaling for Virtual Learning	SQ2, SQ3

Central Research Question

What are the lived experiences of virtual middle school students during cognitive disengagement and signaling? The participants' shared the perspective that virtual learning is an enjoyable experience because they have the freedom to learn in a way that is empowering to them as individuals. All participants were able to describe situations in which exceeded their cognitive threshold, were metacognitively aware of their mental disconnection, and how (at times) their brain felt like an external entity that reacted contrary to their directives thus inhibiting comprehension. Participants expressed that they were able to overcome their cognitive blockades when they employed specific learning strategies. They perceived multimedia cues as providing a different approach to understanding and an effective way to manage channel modalities. Bootes explained:

> Today, the one that took two hours was that science lesson, but it was a really good two hours because I absorbed all the knowledge. We went into it, and we'd had done part of it yesterday. And then, my brain just turned off basically. We came back to it today with a fresh mind, and it was like I picked up all the information—and I wasn't getting it at all. Until, my mom said something. Then, it all clicked in my head. [head explosion gesture] I was taking it directly as the words were when—this happens to me a lot—I then need, like sometimes I need my mom will say it in a different way. And then, it's like completely unclicks in my head [key turning on head gesture] like someone just turned a key.

Sub-Question One

What are the perceived causes of cognitive disengagement in virtual middle school students? According to the 15 participants, cognitive disengagement is caused by surpassing the mental threshold or capacity through overloading sensory channels or redundant monotony. The middle school participants indicated awareness of cognitive overload due to external as well as internal factors. They surmised that imbalanced lesson structure (devoid of multimedia or interactives) along with distractions would lead to mental overload. There were many perceived internal factors that cause cognitive disengagement; although, the unifying agreement was that these internal factors may be conscious decisions (such as self-deprecating motivation) or may not be and the brain is going rogue. Phoenix referred to this as "un-zombie mode" while Aquila expressed:

> Today, I had a lesson that was 24 pages long—so if it's that long, then I don't like it. I'll do it if I *have to* [emphasized]. Otherwise, I'll do part of it one day and then do the other part hours later or either the next day because my brain can't comprehend that much

> information on one subject in that short amount of time. So, I guess if it's like super long or if I just don't find it interesting, then I just kind of have to force myself to do it, even though I don't like it or… I'll try to reread something over and over again, but my brain still won't comprehend it.

Sub-Question Two

How do middle school students describe the influence of signaling on cognitive disengagement in virtual learning? There was a combined expression of enjoyment for online virtual learning due to the freedoms of scheduling and student driven independence. Participants shared an appreciation for virtual education's opportunity to customize learning to best meet their individualized preferences. Signaling (as a type of multimedia learning) was perceived to combat cognitive disengagement by directing learners' attention to important information without using valuable, limited mental capacity on sifting through extraneous content. According to participants, balancing modalities with multimedia cues amplified participants' engagement without thrusting them into cognitive overload. During the individual interview Draco showed examples of various pages in a "confusing" math lesson. He explained:

> I didn't like this lesson because the information was nice and sorted. I ignored this page. He's kind of just like going back and explaining something I already know…Honestly, just have a better example. [This page is] splitting. It's kind of just like splitting thing sup without any explanation. I don't know how to explain this page. I really didn't like it because there's too much information being thrown at me. Same here. Just information being thrown at me.

Conversely, Draco shared in the Friday focus group chatpod, "Gamification kinda [*sic*] works for me? Idk [*sic*; I do not know], just throwing the idea out there."

Sub-Question Three

What type of signaling (if any) is perceived by middle school students as most effective in virtual learning? Due to the individualized nature of virtual education, the 15 participants perceived signaling as being subjectively effective based on the context and their own personal preference. The collective lived experience was that participants found cues to be beneficial to discerning important information and assisting with re-engagement. Additionally, they would recommend identifying and utilizing cues to their classmates. According to participants, the effectiveness of the signal "depends" on if it is used in resources, used by others, or used in learner-created notes. Lupus expressed:

> Well, it kinda [*sic*] depends. If it's in word form or text form because it's in text form, it's usually in bold or underlined, different color—which usually indicates if it's—like what [Phoenix] said—it could be an emphasis of the lesson or main topic or speech. Like they emphasized a word or that main topic or something like that…I feel the pictures are slightly better than the image because on the bolding one, it kinda [*sic*] blurred out the other images. But, it kinda [*sic*] depends because in the text, you can't really do that because the text has some purpose to explain the bolding there. And, the bolding has purpose in the text. So, it still stands out but not as much as in the image.

Summary

The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. There were three themes and six subthemes that emerged from the collective lived experience of the 15 middle school participants. The three themes were student empowerment through virtual learning, cognitive threshold processing, and virtual learning

strategies. Likewise, the six subthemes were freedom to learn, student driven, metacognition, the rogue brain, augmenting modalities with multimedia approaches, and effective signaling for virtual learning. Moreover, there were two outliers that all participants shared: breaks and being setup for success. The 15 self-identified, intrinsically motivated participants shared the perception of thriving in an online learning environment. According to participants, virtual education offers a truly personalized experience in which scholars have the freedom to learn in their chosen best practice manner. One hundred percent of these middle school students not only experienced cognitive disengagement but were able to provide explicit scenarios in which their mental capacity was overwhelmed. Cues were perceived to help participants locate important information quickly; however, once cognitive overload was reached, learners utilized breaks to restore their mental threshold. While the participants did acknowledge their susceptibility to distractions, they capitulated how signaling can be leveraged as a multimedia tool to combat cognitive disengagement.

CHAPTER FIVE: CONCLUSION

Overview

The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. The 15 volunteer participants attended Rigel Virtual School located in the Midwest United States. To qualify as a candidate, participants needed to be in seventh or eighth grade and self-identify as a motivated learner. They brought unique perspectives and shared moxie of enjoying virtual learning, experiencing cognitive disengagement, and interacting with signals. Chapter Five culminates the thorough analysis of the raw data collected from the individual interviews, questionnaire, and focus groups. This chapter provides a critical discussion of interpreted findings, and implications for policy and practice. Likewise, empirical and theoretical implications are investigated along with presenting limitations and delimitations. This chapter concludes with recommendations for future research.

Discussion

Twenty-first century learners and families have a variety of educational delivery options. Virtual schooling is on the rise yet understudied due to its relatively short duration in the history of education (Beeman, 2022; Toppin & Toppin, 2016). The leading attractions to virtual education are flexibility, student-centered focused, and high rigor (Agustini et al., 2022; Eden et al., 2022; Li et al., 2023; Xiao et al., 2020). The first theme and two subthemes corroborated these attractions. Students feel empowered through virtual education due to the freedom to learn and individualized opportunities to customize the learning experience to meet their preferences. Columba shared, “I’m doing more challenging classes, but I’m also doing learning a way that fits me, specifically. It just works for me.”

In virtual education, the responsibility of learning primarily resides with the learner. Consequently, student retention is maintained through engagement (Piscitello et al., 2022). According to Li et al. (2023), positive perceptions of self-directed learning skills and academic emotions predicted higher engagement in online learning, and cognitive engagement is defined as the ability to maintain capacity and stamina while interacting with online curriculum. A qualification to participate in this study, a student needed to self-identify as intrinsically motivated. Likewise, all 15 participants expressed a positive perception of virtual learning.

Although one hundred percent of participants shared the lived experience of cognitive disengagement, this did not significantly deter their academic productivity. The second theme and two subthemes corroborated this. Participants were particularly resilient when it came to their cognitive threshold. They were highly reflective in their metacognition, but these middle school scholars did perceive occasional instances in which their brain went rogue or acted in contradiction to their desires. Phoenix explained, “I could be overwhelmed, but I’m telling myself not to. I don’t know if that’s true or false, or if it’s something that my brain has created, and I can handle more. I’m probably fine.”

Additionally multimedia plays a significant role in engagement in virtual education with the advancement of technology (Leidner & Roch, 2024; Magana et al., 2022). Signaling is among these forms of multimedia that reduces split attention by directing learner focus to critical information (Ginns et al., 2020; Moon et al., 2022; Pi et al., 2021). The third theme and two subthemes corroborated this. There were many virtual learning strategies that the participants collectively agreed upon. In particular, augmenting modalities with multimedia along with signaling provided effective approaches to balance cognitive architecture and extend working memory’s limited capacity.

Cognitive architecture is composed of the three cognitive loads of short-term or working memory: extraneous (ECL), germane (GCL), and intrinsic (ICL) (Sweller, 2011, 2020; Sweller et al., 1998). Participants actively reduced their ECL by striving to study in a quiet environment. They not only recognized signaling in resources and from others but would utilize cues in their own notes to streamline ICL and promote GCL's schema formation. As the name suggests, multimedia combines visuals and text intentionally to avoid overloading one channel (Altan & Cagiltay, 2022). This study found that block paragraphs or lessons with limited images would result in overwhelming the participants' visual channel. On the other hand, loud noises or monotone delivery would negatively impact the auditory channel.

Digital literacy consumes mental capacity which can restrict a student's ability to comprehend the content. Although, Almasseri and AlHojailan (2019) warned that virtual products can take more mental capacity due to the higher sophistication of work required. This should especially be taken into consideration when educators are integrating new technology tools. Aquila highlighted:

> I guess the most memorable one was like in the first few weeks or months at [Rigel virtual school]. I was so kind confused on everything and didn't entirely know how it worked. So, like she [mom] sometimes helped me go over the lessons and like helped me figure out what to take notes on and what not to.

In this section, the three themes and six subthemes will be further analyzed. Along with a critical discussion on the interpretation of findings, implications for policy and practice will be addressed along with theoretical and empirical implications. Moreover limitations, delimitations, and recommendations for future research will be acknowledged.

Summary of Thematic Findings

The central research question of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. Unanimously, the 15 participants perceived empowerment through virtual learning, shared the lived experience of the cognitive overload phenomenon, and leveraged virtual learning strategies (such as signaling) to combat disengagement. The first sub-question investigated the perceived causes of cognitive disengagement. The participants collectively shared awareness of cognitive overload due to internal factors (such as lacking motivation) and external factors (such as distractions). Moreover, participants perceived their rogue brain causing cognitive disengagement through its inability to process sensory information. As a result of the second sub-question, participants agreed that signaling can prevent cognitive overload and streamline re-engagement; however, breaks were the leading solution once mental capacity has been superseded. While there was not an all-encompassing effective signal identified in the third sub-question, participants did perceive alternative multimedia approaches to augment modalities to meet their individualized learning preferences.

A Critical Discussion

The multifaceted nature of the central research question and three sub-questions resulted in distinct insights. There were three themes and six subthemes. The three themes were student empowerment through virtual learning, cognitive threshold processing, and virtual learning strategies. The six subthemes were freedom to learn, student driven, metacognition, the rogue brain, augmenting modalities with multimedia approaches, and effective signaling for virtual learning. The themes and subthemes were established on a firm basis of the online environment;

hence Sweller's (1988) cognitive load theory (CLT) and Mayer's (1999) cognitive theory of multimedia learning (CTML) were justifiable foundational theories (Alpizar et al., 2020). The following critical discussion will analyze how the cognitive pathway, the virtual middle school scholar, and signaling works are connected to the established foundational theories and corresponding themes and subthemes.

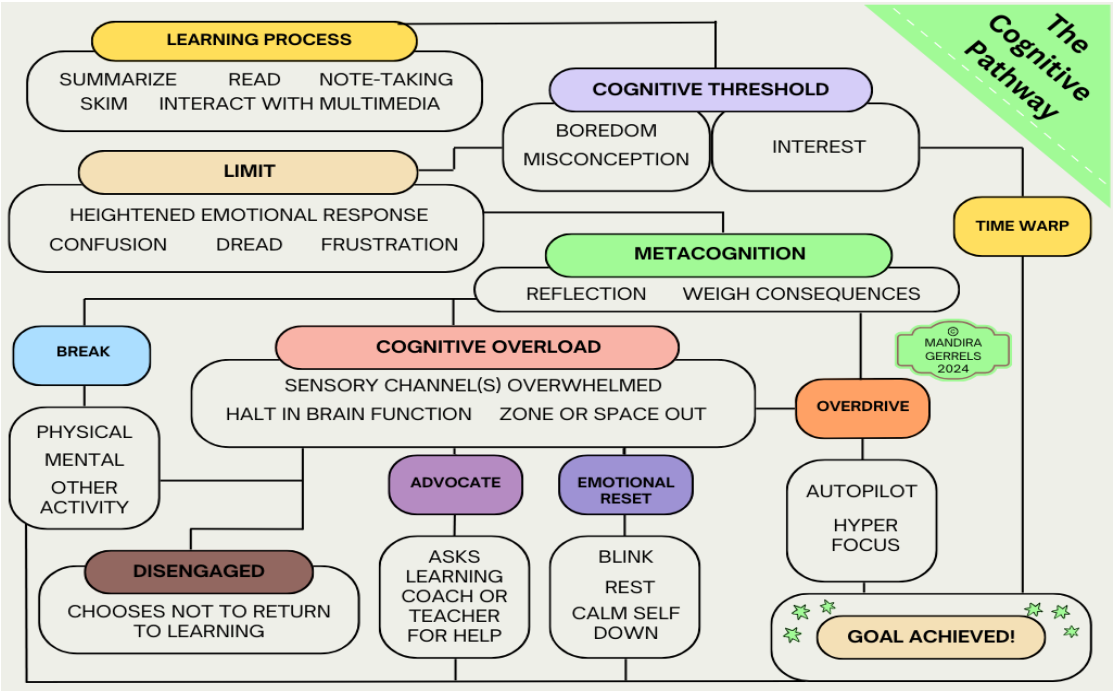
The Cognitive Pathway

According to CLT, the objective of learning is schema acquisition or bundling new information into packages with prior knowledge to be stored in the unlimited space of long-term memory (Sweller, 1988, 2011, 2020). Additionally, the cognitive pathway has evolved as a consequence of technologies' integration (Anmarkrud et al., 2019; Skulmowski & Rey, 2020). The 15 middle school participants of this study collectively shared experiencing the cognitive process which transcends learning through cognitive overload. This is illustrated in Figure 6 below.

All participants described their learning process as involving interacting with multimedia (interactives and videos), reading, skimming, and summarizing. Likewise, 14 participants (save Pyxis) take notes. As they complete a lesson, their cognitive threshold determines if the information is interesting (Aquila), boring (Draco), or inducing misconceptions (Taurus). If the information is deemed relevant or valuable to the individual, then it is stored in long-term memory for later recollection (Bahari, 2022). Aquila shared that when she finds content interesting, she is compelled to "look up" more information. Moreover, enjoyable learning can lead to a time warp phenomenon described by Lupus, Phoenix, and Tucana in which focused stamina is maintained for an uncanny amount of time. Tucana capitulated, "If I get into a game or like watching the show…and all of a sudden, it's bedtime, and I'm like, 'What? No, it's not.'"

Figure 6

The Cognitive Pathway



Note. This image shows the cognitive pathway as described by the collective lived experiences of the 15 participants in this study. In possession of: Mandira Gerrels.

Depletions of Mental Capacity

On the other hand, the mental process can deplete and reach a limit due to misconceptions and boredom which can transform into confusion (Rodemer et al., 2022). Draco iterated that when the "questions are too hard," he will "disconnect from it…out of boredom because, you know sometimes the lesson just doesn't click with me." Bootes also provided a detailed example where he held a misconception regarding a math problem. Magana et al. (2022) explained that dismantling misconceptions can be extensively difficult—especially if the information has already been organized into an automized schema. Students could potentially

overcome this by being taught how to simplify their mental routines and heighten awareness of their cognitive pathway (Novak & Schwan, 2021).

Along with confusion, the limited mindset begins elevating emotions as participants began processing dread and feeling frustrated. These emotions can expedite metacognitive reflection and induce cognitive overload as affective engagement cannot be analyzed independently from cognitive engagement (Eden et al., 2022; Magana et al., 2022). Five participants shared this lived experience. Columba explained:

> I'm kinda [*sic*] similar to [Bootes] in that if I try to do schoolwork when I'm just at a point in time where I cannot focus on anything, I *don't* [emphasized] focus…I can't force myself because otherwise, I just won't focus, then I'll panic.

Additionally, Pyxis and Phoenix shared an expression of "dread." Pyxis wondered if he "seriously had to remember all" of the video information. Phoenix expressed:

> I don't want to call it dread, but it's a bad feeling. It's not a happy feeling…sometimes I can be a little short, and she'll [mom] just leave to see when I'll calm down, and at that time, I'll just keep going with the lesson.

Jopling et al. (2021) indicated that these biological stressors can interrupt student focus and working memory function. If students are experiencing this during class, educators can either lower challenge expectations or provide more scaffolding for the activity (Baten et al., 2020). Extra framing is particularly beneficial for middle school students as they tend to be more concrete thinkers (Bolkan & Goodboy, 2020; Piaget, 1964; Schunk, 2016). Three participants indicated that they tend to disengage or "space out" from the multimedia videos. Interactives in online programs that contain signaling cues can streamline mental processing, so students can not only maintain a reasonable cognitive load but also feel success and ownership in their

learning (Bone et al., 2023). However, instructional designers and teachers should still designate specific learning tasks to guide focus (Liu et al., 2022).

Metacognition

Pending that participants did not immediately go from a limited cognitive threshold to overload, some participants would pause and think about their thinking. This study was chosen to imply a transcendental phenomenological methodology due to the analysis of internal emotions and metacognitions of the learners (Moustakas, 1994). During this stage in the cognitive pathway, participants would weigh their capacity and consequences to determine their next action. For example, Phoenix processed, "I think I might not want to work until 8[pm]. It's like a subconscious deadline to get to this one point. It does and doesn't matter if you've gotten the lesson done." If she determined that "It's not going to affect me now," then her pathway moves on to halting brain function and disengagement. Alternatively, Phoenix surmised that she has also taken a break or "you go back to work and your brain just kind of decides to speed up into overtime."

Preventative Signaling Techniques

Signaling can prevent students from reaching cognitive overload if used to draw learners' attention quickly and efficiently (Ring et al., 2021). Just as Mayer (2017) expressed that there is no prescribed method, this research found that effective signaling in the virtual learning setting depends on the individual learner and situation. Although, there were many research examples that were validated in this study. For example, summarizing or concrete examples are forms of signaling that may help with retention of information (Bolkan & Goodboy, 2020). Cassiopeia highlighted that summaries provided by teachers on the "intro pages" put her in the right frame of mind quickly. Graphic organizers are a form visual signaling that assists germane cognitive

load (GCL) combine new and prior knowledge into schemas (Bahari, 2022; Beege et al., 2021). Bootes confirmed that charts, concept maps, and graphic organizers are effective ways to streamline mental processing (Bacca-Acosta et al., 2022; Bahari, 2022; Krieglstein et al., 2022b). He indicated that his teacher uses "diagram" to present the content quickly and in a different way. Furthermore, the use of two monitors can prevent cognitive overload because the learner is not experiencing split attention from toggling between multiple browsers or tabs (Miller et al., 2020). Both Bootes and Lupus shared that they have a "secondary screen." Lupus would have "my quiz on my main screen, then my lesson on my second screen."

Overwhelming Sensory Channels

According to participants the cognitive overload phenomenon is primarily the result of overwhelming one or more sensory channels. Dual processing is one of three assumptions that the CLT and CTML theoretical frameworks operate upon (Alpizar et al., 2020; Arslan-Ari & Ari, 2021). Dual processing was initially derived from Clark and Paivio's (1991) dual coding theory. As working memory actively sifts through the environmental stimuli taken in, the three loads of cognitive architecture (extraneous, germane, and intrinsic) are balanced (Sweller et al., 1998). Content is most readily comprehended when the information is spread across multiple channels rather than overwhelming one—such as lengthy block text or having too many words (Clark & Mayer, 2016; Clark & Paivio, 1991). Visual combined with verbal integration can lead to new schema acquisition (Mutlu-Bayraktar et al., 2019). As participants remarked on their cognitive overload experiences, many referred to their brain as an external entity. Bootes reflected:

> Normally, if I'm misunderstanding something, and I can't figure out what's happening. It's kind of [like] my brain shuts down or, tends to shut down, and tends to be like 'I don't know what's happening, I can't do anything.' and then, the brain breaks down.

There are multiple responses that participants reported. The most pronounced (and the first outlier) was taking a break. Participants defined a break in a plethora of ways from physical activity such as "going for a walk" (Aries) and yoga (Norma) to doing something enjoyable such as "reading a chapter" (Columba, Phoenix, Virgo) or watching an "episode" of their favorite show (Cassiopeia, Tucana). Restoring cognitive capacity can even been simple acts such as resting one's eyes or disconnecting from the screen (Paas & van Merriënboer, 2020; Sweller, 2020). Taurus corroborated that he will "read my book or blink…put my head down." Moreover, Columba also identified the need for affective balance. "I go back, and I'm in a neutral mood or a good mood. It depends, and I can focus." On the other hand, Draco shared, "Open honesty? I don't know. Eventually, I just kind of like go back to it."

Reengagement through Signaling

Reengagement is an opportune time to leverage signaling—especially if the content is complex (Eitel et al., 2020). This study showed that the middle school participants were not aware of the benefit of reviewing their own signaled notes. Along with five other participants, Columba expressed taking a longer approach, "I go back to the beginning, it's a bit of a waste of time, but it's really the only way I'm able to absorb the information without being super overwhelmed." Educators could directly practice reviewing signals in resources and notes to save mental duration and capacity upon reengagement. Ten participants identified explicit directions as an effective form of verbal signaling.

In contrast, there were participants who admitted to electing to not re-engage. According to Asim et al. (2020), middle school students are at greater risk for academic failure due to losing focus and cognitive disengagement. Vulpecula corroborated Phoenix's following sentiments:

> I'm going to be honest, sometimes I don't. It's either where sometimes I just want to be done for the day or it's fantasizing being done for the day…with the laziness times, it's where I'm just not into it. I feel like—it's the same thing. The schoolwork is in the back of my mind, but the *Encanto* or daydreaming looks more enticing.

The time of day or being in the right mood were factors for Bootes and Columba, respectively, that determined whether or not they would continue learning or work later.

On the other hand, time and mood factors pushed some participants into overdrive. Aquila and Draco indicated that they will "push" through the lesson. Lupus shared, "I kind of agree with [Phoenix] on that. I kind of keep going. Just keep trying to get all my work done." Through direct instruction, leaners could transform their autopilot mode into effective automation which is the unconscious building of concept relationships while fostering GCL in schema acquisition without the depletion of learning energy (Krieglstein et al., 2022a; Sentz et al., 2019; Wang, 2021).

Implications for Policy or Practice

Selecting appropriate educational settings and best practices are important decisions for policymakers, educators, and instructional designers alike. Quality instruction in virtual learning is necessary to empower students as online education continues to expand (Andersen & Makransky, 2020; Xiao et al., 2020). Apart from accessibility policies, federal and state policies around virtual education have primarily addressed the allocation of resources for distance learning during the COVID-19 pandemic. As virtual learning is highly individualized, careful

consideration should be taken based on the student's learning preferences and motivational characteristics. Similarly, multimedia integration should be thoughtfully selected and not utilized just for gamification's sake. Accessibility and consistency should also be taken into consideration with implementation. As this research indicated, cognitive disengagement is a likely archnemesis for virtual middle school scholars that can be combatted through the leveraging of signaling.

Implications for Policy

Virtual learning does not hold the expansive history as education; therefore, there is limited policy and research for the online setting (Ford, 2022; Toppin & Toppin, 2016). Unfortunately, online students tend to academically perform significantly lower than their in-person counterparts (Xiao et al., 2020; Zhang & Lin, 2020). Part of this conflict is the result of virtual students being held to the same standards, but virtual learning must operate differently (Beldarrain, 2006). All participants of this study shared the perception that virtual learning is empowering and effective for them due to its flexibility and freedoms to learn their way. Future policies should take into consideration who is allowed to be a virtual learner and accommodate the ubiquitous schedule of online learners.

After the global COVID-19 pandemic, distance learning gained more attention—particularly with concerns for affective (or emotional) and social engagement (Beck et al., 2022; Carter et al., 2020; Piscitello et al., 2022; Wang et al., 2019). Academic achievement is strongly correlated with cognitive engagement (Xie et al., 2020). This research supports this sentiment as well as the need to have a strong drive and intrinsic motivation. As more school districts begin providing alternative virtual learning opportunities to the families they serve, it is highly recommended that thorough discussions and vetting is performed before allowing students to

transition. Success on the digital frontier primarily lies on the individual learner; hence, virtual learning is not an appropriate platform for every scholar. School districts should also consider the accessibility of multimedia and be intentional about its use.

Implications for Practice

The integration of multimedia learning has already had significant implications in professional and post-secondary settings in the form of simulations and gamified educational technology (Liberman & Dubovi, 2023; Magana et al., 2022). Signaling is among the forms of multimedia learning that assists in managing learners' cognitive load and reduce split attention (Ginns et al., 2020; Moon et al., 2022; Pi et al., 2021). As middle school students are at high risk for disengagement (Asim et al., 2020), it may be helpful to implement signaling into virtual instruction. This research indicated that signaling helped participants locate the important information faster, maintain focus longer, or reengage quicker. The implications of explicit instruction, repetition, and integrated cues may also be beneficial for primary and secondary students as well as on other virtual education platforms.

Additionally, online learning adds a cognitive dynamic as the inclusion of technology is another component requiring mental processing (Guo et al., 2020; Li et al., 2020a, 2020b). All participants shared the lived experience of being overwhelmed when they first transitioned to virtual education. It was beneficial to address more complex or important topics after they learned how to navigate the system. This could be extrapolated to new, dense concepts in general. In other words, students needed to learn the multimedia first before comprehending any content. When introducing a new gamified program, make the content relatable such as testing prior knowledge or reviewing first.

Moreover, there were several participants (like Aquila and Pegasus) who indicated that they would ask "unanswerable" questions as a defense mechanism to lower this cognitive threshold. Aquila quipped, "I usually just think of something stupid or dumb. Ask people dumb unanswerable questions…so my brain doesn't have to think as much." This may be a signal that middle school students are reaching mental capacity and need a brain break. Whether students initiate brain breaks or teachers do, minor tangents could be beneficial to learning in the virtual setting.

Empirical and Theoretical Implications

In this post-pandemic world, K-12 virtual education continues to expand (Li et al., 2023). This research is among few studies dedicated to analyzing middle school virtual education. Additionally, cognitive engagement is studied less frequently than the other types due to the difficulty of measurement (Wang, 2021; Xiao et al., 2020). The empirical and theoretical implications of this study indicate that a gap in the research has been addressed.

Empirical Implications

The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. The qualitative approach was specifically selected. Metacognition or thinking about one's thinking was a subtheme resulting from the collective lived experiences of the 15 participants. This subtheme lies at the center of the qualitative methodology (Doherty, 2022; Klepsch & Seufert, 2020; Mayer, 1999, 2014, 2017; Moustakas, 1994; Xu et al., 2021). Signaling had been previously verified as a best practice strategy to combat cognitive disengagement as cues can circumnavigate extraneous information and direct learner's attention (Bolkan & Goodboy, 2020; Eitel et al., 2020; Ginns et al., 2020; Ring et al., 2021). The

empirical implications of this study captured that freedom to learn, and balancing channels are perceived as critical components for virtual education success.

Theoretical Implications

The results of this study corroborated the three assumptions that ground cognitive load theory (CLT) and the cognitive theory of multimedia learning (CTML): dual processing channels, limited capacity, and active engagement (Alpizar et al., 2020; Arslan-Ari & Ari, 2021; Clark & Mayer, 2016; Sweller, 2020). The curriculum at Rigel virtual school integrates many different multimedia features that are created by corporate (Orion) and teachers. The participants discerned perceived effective and ineffective lesson layouts. On the one hand, Phoenix shared:

> Learning is me having a good grasp on what they're trying to communicate. I know what they're trying to communicate. I know what they're trying to say. I'm not having to decode any inferences…You have like the earth science videos and the earth science lessons. You can't just do the video because you won't know as much.

In contrast, Aquila indicated:

> If there's like *way too much* [emphasized] going on. Like there's four videos and like 13 or 14 pages and then like a test, quick check, or practice. It's just like a *lot* [emphasized] of information, and it's not ordered. Then, it's just the bad kind of chaos.

The balancing of channels was a subtheme in this research. In particular, all participants commented on impact of the auditory channel. This ranged from watching the videos, to using screen readers like "Libby," or asking their learning coach to read the passage aloud. Vulpecula described:

> There were two different times. One time where I couldn't figure out how to get somewhere [navigating the online classroom] and other people were having the same

> problem. She posted and just sent a video for us to help find that [and] was explaining where to go to get it. And then another time, again, a few other kids were having the same problem. She helped us figure out where to go by like screen sharing and showing the whatchamacallit. Most times, they repeat it or show us different versions of the same thing.

The combination of the visual in the screensharing with the verbal explanation helped participants process the content.

Grounded in Baddeley's (1986) theory of working memory, the second assumption states that mental capacity is limited. Working memory is the active learning center that processes inputs and builds connections between prior knowledge to new knowledge (Krieglstein et al., 2022b; Sweller et al., 2019). This is most readily done through balancing cognitive architecture: extraneous (ECL), germane (GCL), and intrinsic (ICL) (Sweller, 2011, 2020; Sweller et al., 1998). Typically, ECL is induced by the resources or the educator as extraneous or irrelevant information is being processed and thus using mental capacity (Alpizar et al., 2020; Miller et al., 2020). Aries acknowledged there can be an "unnecessary amount of videos," and Draco noticed "a lot of page in my assignments are just filler or review pages." These extraneous features led to cognitive overload.

Germane is less researched than the other cognitive loads due to its ambiguity of converting working memory knowledge into long-term memory (Altmeyer et al., 2020; Bahari, 2022). Bootes expressed that his mom will explain content:

> …in like videogame kind of terms or something. Like, turned it in into something I could understand, and then my brain immediately went like, 'Hey, I recognize that! I can take

> this information now.' And so then, whenever I need to take in more information, I just turn it into that scenario in my head.

Intrinsic cognitive load fluctuates based on the learning goals, complexity of the condense, and expertise of the individual (Magana et al., 2022). Columba described a manageable learning situation has having one topic per page. Norma leveraged her prior knowledge when she "just couldn't figure out that one problem." Likewise, participants perceived easier lessons—especially when multimedia is involved—as less likely to induce cognitive overload. Pegasus shared, "Well, the interactives are kind of easy. Not too much stress." On the other hand, Bootes and Pegasus each cited a detailed example in which they spoke to an expert that caused them to go into mental overload. Bootes shared:

> I got one! So, the other week, I was at my grandpa's house, and he is getting his pilot's license. So, he'll be talking to me—something about flying—and eventually I just told him, 'I have no idea what you're talking about. My brain cannot keep up. I'm just here to have fun.' And then he's like, 'Okay.' And then, I'll explain something, and he'll be, 'I don't know what you're talking about.' So, we both like mutually agree that we have to like *dumb* [emphasized] it down in a way.

Similarly, Pegasus shared conversing with experts when he volunteers at a World War II museum. "These guys will be talking about these planes, and I have *no idea* what they're saying." He also provided the example of his grandma not understanding "a meme."

According to Magana et al. (2022) and Sweller et al. (1998), the distinction between expert and novice lies in the number of schemas held. Experts have more complex built schemas to recall information. This study supports this because participants shared having a significantly lower threshold for new information and experiences. Lupus, Pegasus, and Phoenix all cited the

"first day of school" because of the unknown (or not knowing what to expect). Columba indicated that she was both "excited" and "anxious" because she "was worries that it would be stuff that I don't understand at all, but I do understand it pretty well." Columba also recognized how content gets progressively more difficult as the school year goes on. Comparably, Aquila acknowledged that the first week involved "a bunch of stuff that I had *never* [emphasized] heard about before."

This research did diverge from research as enjoyment perceived to have a larger impact on middle school engagement. If participants enjoyed the activity, then they were able to focus for longer. Moreover, if the content was "relevant" to the learner (as Aries indicated), then participants would also perceive more value. Virgo explained:

> Say you believe in something more than you believe in another thing, you'll usually pay more attention to it. And then, if you know what you're reading or looking at, something will just stick out more to you. Like if you're reading a book about cats, and you have a cat, you'll probably pay more attention to the paragraph.

Emotions can also impact mental capacity (Patel & Alismail, 2024). The middle school participants in this study corroborated how getting "upset" (Cassiopeia), "irritated" (Tucana), or "frustrated" (Tucana, Phoenix, Virgo) can lead to diminished focus. Cognitive engagement is connected with the other types of engagement: behavioral, emotional, and social (Bergdahl et al., 2020; Wang et al., 2019a). Moreover, the feeling of inadequacy can hinder cognitive capacity due to the fear of failure (Baten et al., 2020). Five participants self-identified as "perfectionists" and described the debilitating effect incorrect answers.

The third assumption of CLT and CTML is active learning. While identifying as a self-motivated learner was a criterion for candidacy, 13 participants modeled this in their dedication

and thoroughness of responses to the individual interview, questionnaire, and focus group. Virtual learning resurrected self-regulated learning (SRL) as online scholars developed metacognitive skills to maintain academic performance (Carter et al., 2020). This was supported by this study as participants were aware of their mental limits and aware of their level of learning mindset. Draco quipped, “I’m trying to remember because I have the memory of a goldfish,” and Aquila shared, “Sometimes my attention span for stuff is really small.” Moreover, Bootes physically represented this as he stared unresponsively during his afternoon individual interview. He responded, “Could you repeat your question? I’m sorry, it’s past that time of day.” Being aware that he is a morning learner, Bootes prioritizes lessons based on his capacity.

There was clear distinction from the participants in regards to the role of signaling. According to the participants, cues can help as a preventative measure to combat cognitive disengagement or signals can help re-engage learners quicker; however, while experiencing mental overload, breaks were the unanimous solution to lower cognitive threshold.

Limitations and Delimitations

The research contained limitations and delimitations. One limitation was the result of an error by the researcher. In the questionnaire, one of the options was duplicated as a correct answer in question #4 of the signaling example sort video. Participants who select the horse for highlighting or bolding were both counted as correct. The Friday focus group brought this error to the researcher’s attention. The data collection methods presented the most common cues addressed in the literature rather than an exhaustive list of signaling types. Embodiment signals (dynamic drawings, kinesthetic cues, and facial expressions) were not included in this study.

Additionally, there were limits with the volunteer participation. Pyxis did not thoughtfully complete the questionnaire and did not attend the focus group. Taurus logged into

the focus group and immediately left without returning. Taurus acknowledge that he would complete the questionnaire but did not. Pyxis and Taurus were fully compensated despite their limited participation. While all participants were able to use webcam and microphone during the individual interviews, there were some participants who experienced technical difficulties during the focus group. Aries was unable to use her microphone. Although her webcam worked, she refused to turn it on. Norma had her webcam on but refused to use her microphone. The majority of the Friday focus group participants elected to use the chatpod.

The delimitations of this study were carefully selected to fill the gap in the research and vetted by the IRB. The participants for this study were recruited from Rigal virtual school located in an upper Midwest American state. This site was purposefully chosen due to the robust curriculum and longstanding, prestige of this nationally accredited private institution. While Rigel operates under the parent company Orion (which builds the curriculum), individual virtual schools have the ability to supplement learning; therefore, one site was selected for uniformity. Causes of disengagement can be more readily analyzed if course structure, pedagogy, and academic supports are uniform (Barbour, 2022).

Additionally, seventh and eighth grade students (ages 11-14) were intentionally picked for the target group due to the gap in the signaling and multimedia research (Bolkan & Goodboy, 2020). The purpose of this study was to review how technology can help this particular age group learn (Bone et al., 2023). Sixth grader students were ineligible for participation to prevent any unethical risk for academic conflict as the researcher taught sixth grade at Rigel during the time of this study. Racial and gender demographics were not considering factor; however, the researcher did strive to balance (and successfully achieved) representing the overall school population. Details on participant demographics can be found in Appendix L.

Recommendations for Future Research

Middle school scholars selected for this study because they were an unrepresented population in the research. This age group proved to be highly capable of articulating their experiences (Webb et al., 2022; Zhang & Lin, 2020). It is suggested that signaling research continues into elementary education to investigate when students become aware of their learning process such as the ability to identify when they are mentally overwhelmed and how to identify important information.

Moreover, one hundred percent of participants expressed having dedicated learning coaches (parents) who supported their educational journey as well as distinguished learning environments. While not a direct focus of this study, all participants did acknowledge environmental and parental impacts. It would be interesting to analyze the influence of parent involvement and comfort of the home learning environment on students' academic success.

There were limitations and delimitations in this study that could provide opportunities for future research. For instance, not all forms of signaling were assessed. Embodiment signals would be another opportunity to investigate. Furthermore, signaling cues target dual channel supports. Exploring accessibility and inclusive strategies for students with exceptionalities would be another future research opportunity. Moreover, only one site was selected in this study. Future research could expand the geography or number of sites compared.

While participants were not expected to present notes, many showed their own signal-rich notes. A future study could investigate notes as artifacts to take a deep dive into understanding what information is deemed relevant by the learner. On the other hand, a quantitative study could be employed to determine in which scenarios a particular signal worked best. The middle school students of this study did acknowledge difficulty with summarizing.

How could the new technology tool of Generative AI support their digital literacy and skill development? Likewise, more research should be conducted on the virtual education, specifically as technologies continue to evolve.

Conclusion

Virtual education provides an intimate learning experience in which self-motivated scholars can especially thrive. School districts and parents should think carefully of the individual learner and evaluate if the online setting is best suited. The purpose of this transcendental phenomenological study was to understand the lived experiences of middle school students leveraging signaling to combat cognitive disengagement in virtual learning. According to the 15 participants who attended Rigel virtual school (located in an upper Midwest American state), cognitive disengagement occurs when too much information overloads one particular sensory system such as auditory (i.e. loud noises) or visual (i.e. chunky paragraphs). Depending on the learner and situation, the participants perceived a reduced processing capacity that could be alleviated through the leveraging of signals; however, once cognitive overload is reached, it is best to employ breaks. As virtual education lends itself to multimedia learning, educators and instructional designers can easily integrate engaging learning experiences. Cues (such as bolding, explicitly stating, or icons) can help direct the learner's attention to important information. Most notably in middle school education, summarizing and gamifying content were also identified as beneficial. As Phoenix highlighted, there is a trust established between the virtual scholar and the content; therefore, instructional designers and educators should take pride in creating high quality resources. Be "like a wise man who built his house on the rock," (Matthew 7:24, NIV, 2020). Thus, virtual student engagement can then lead to high retention and graduations.

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Appendix A

Liberty's IRB Approval

Date: 8-31-2023

IRB #: IRB-FY23-24-103
Title: LEVERAGING SIGNALING TO PREVENT COGNITIVE DISENGAGEMENT IN VIRTUAL MIDDLE SCHOOL STUDENTS: A TRANSCENDENTAL PHENOMENOLOGICAL STUDY
Creation Date: 7-23-2023
End Date:
Status: Approved
Principal Investigator: Mandira Gerrels
Review Board: Research Ethics Office
Sponsor:

Study History

Submission Type Initial	**Review Type** Expedited	**Decision** Approved

Key Study Contacts

Member Carol Gillespie	**Role** Co-Principal Investigator	**Contact** [redacted]
Member Mandira Gerrels	**Role** Principal Investigator	**Contact** [redacted]
Member Mandira Gerrels	**Role** Primary Contact	**Contact** [redacted]

Appendix B

Orion and Rigel Site Approval

July 25, 2023

Dear Mandira Gerrels:

On behalf of the Research Review Committee at [redacted] *Leveraging Signaling to Prevent Cognitive Disengagement in Virtual Middle School Students*, has been approved. All research must be conducted in accordance with the approved submission. Please contact me at Alyssa.W[redacted] with your questions and/or proposed modifications.

Sincerely,

[redacted]

Alyssa W[redacted] Ph.D.
Director, Efficacy & Research
[redacted]

7/25/23, 1:19 PM [redacted] Doctoral Research Proposal

Gmail

Mandira Gerrels <mgerrels@[redacted]

Doctoral Research Proposal

Brad S[redacted] <b[redacted]@[redacted] Tue, Jul 25, 2023 at 9:12 AM
To: Mandira Gerrels <mgerrels@[redacted]
Cc: Alyssa W[redacted] <alyssa.w[redacted]>, Annika[redacted] <an[redacted]>

Hi Mandira,

Thank you for sending this for our review!

I just wanted to note my approval. I am happy to provide a formal approval on letterhead as well.

Alyssa, is there a process that we need to follow to ensure Mandira has the proper access to student data?

Brad
[Quoted text hidden]

Appendix C

Student Recruitment Flyer

Research Participants Needed

Leveraging Signaling to Prevent Cognitive Disengagement in Virtual Middle School Students

- Are you in **7th or 8th grade at** [redacted]**?**
- **Are you between 11-14 years old**?
- Are you **self-motivated to learn and able to read and write in English**?

If you answered **yes** to each of the questions listed above, you may be eligible to participate in a research study.

The purpose of this research study is to learn about how you learn! As a scholar, you have an individual and unique experience when you learn, and sometimes learning can be challenging. Mrs. Gerrels would like to investigate how you find important information while learning and how you maintain focus when school work gets tough.

Participants will be asked to provide their personal learning experiences in three different ways: an individual interview, a questionnaire, and in a small focus group.

- **Individual Interview**: participants will meet one-on-one with Mrs. Gerrels in LiveLesson. Both members will use mic and webcam. The recorded session will only be seen by Mrs. Gerrels (the researcher) and will be audio- and video-recorded. The interview will be approximately 1 hour with 11 questions.

- **Questionnaire:** participants will self-reflect on a 5 question Google Form. This will take approximately 30-45 minutes. Only Mrs. Gerrels will see your submitted responses.

- **Focus Groups:** participants will be randomly assigned to a small group of no more than 5 participants and Mrs. Gerrels. All participants and Mrs. Gerrels will use mic and webcam in LiveLesson. The recorded session will only be seen by Mrs. Gerrels and will be audio- and video-recorded. The focus group will take approximately 1 hour with 7 questions.

Benefits include learning what strategies help you be successful in a lesson, learning what helps you to focus and causes you to disconnect, and learning how to reengage with a lesson.

Participants will receive a $30 Amazon e-gift card upon completion of all three activities. Any participant who chooses to withdraw from the study after the beginning but before completing all study procedures will receive a prorated Amazon egift card: $10 after the individual interview, $20 after the questionnaire, or $30 after the focus group.

If you would like to participate, please have your parent or guardian respond to this WebMail! Mrs. Gerrels will schedule a phone call with your Parent or Guardian and you within 48 hours. A consent document will be sent to your parent/guardian after the initial phone call as well as an assent form to potential volunteer participants.

Mandira Gerrels, a doctoral candidate at Liberty University, is conducting this study.
Please contact Mandira Gerrels at mgerrels@[redacted]

Liberty University IRB – 1971 University Blvd., Green Hall 2845, Lynchburg, VA 24515

Appendix D

Parent Recruitment Letter

Dear [Parent Recipient],

As a doctoral candidate at Liberty University, I am conducting research as part of the requirement for a Doctor of Philosophy degree. The purpose of my research is to understand the lived experiences of virtual middle school students during cognitive disengagement and signaling. I am investigating when middle school students disconnect from learning and what strategies help them to reconnect. I am writing to invite your scholar to join my study.

Participants must be in 7th or 8th grade and be between 11-14 years of age, as well as identify as self-motivated to start lessons on their own, and be able to express themselves in English. If possible, the researcher is looking for an equitable balance of gender and representation of our school's population.

If you allow your scholar to participate, they will be asked to complete three activities: an individual interview (1 hour), a questionnaire (30-45 minutes), and a small focus group (1 hour). The individual, audio-and video-recorded interview will be in Zoom Class (LiveLesson) with Mrs. Gerrels (the researcher) and contain 11 questions; the participants will be given pseudonyms. The Google Form Questionnaire will be sent via WebMail and contain 5 questions. Participants will be given pseudonyms for the audio- and video-recorded focus group sessions in Zoom Class (LiveLesson) with Mrs. Gerrels and up to 4 other classmates at this school answering 7 questions. Your scholar will have the opportunity to review written transcripts for the individual interview and focus group to check for accuracy and confirm agreement approximately one week after the activity. It is estimated that participation will involve approximately 3 hours based on the procedure above (excluding review time as that will depend on the individual participant). Names and other identifying information will be requested as part of your child's participation, but your scholar's information will remain confidential.

To consent for your child to participate, please contact me by responding to this WebMail or by calling me at the number listed below to complete the screening process. A phone screening will be scheduled with your scholar, you, and myself. If your child is selected to participate, a secured encrypted *SignNow* digital consent form will be sent to your WebMail along with an assent form for your child to sign. The consent form contains additional information about my research. If your child choose to participate, you will need to sign and return the consent form to me, as well as have your child fill out the assent form and return it to me. Again, participation is entirely voluntary, and your child or you can withdraw from this research study at any time.

Participants will receive a $30 Amazon egift card upon completion of all three activities. Any participant who chooses to withdraw from the study after the beginning but before completing all study procedures will receive a prorated Amazon egift card: $10 after the individual interview, $20 after the questionnaire, or $30 after the focus group.

Thank you for your consideration,

Mandira Gerrels
Principal Investigator and 6th grade Earth Science Teacher
(You may respond directly to this WebMail!)

Appendix E

Participant Screening Phone Call and Questions

This is a script to be read for a phonecall with parent/guardians and the potential student participant.

Thank you for your interest in the potential participation of my research study. The purpose of this call is to review what participation in the study will look like, complete the screening, and answer any of your questions.

If [student] is eligible to participate, [Parent], you will receive a consent form and [student] will receive an assent form that will recap what we talk about today. The permission forms will be sent via WebMail as an encrypted link to be e-signed in the *SignNow* app. I will need both the forms signed and returned before any participation can begin.

To be eligible, your student must be enrolled in seventh or eighth grade at the virtual charter school Rigel. They must be between 11-14 years of age and self-identify as a motivated learner and proficient in understanding and communicating in English.

The purpose of this study is to investigate the middle school experience of online learning. I, as the researcher, want to find out when [student], as the learner, mentally disconnect from coursework and what helps you to reconnect. This study will also investigate what you perceive to be the best way to help you identify important information in a lesson. As you can hear, there is no right or wrong answers in this study.

If you are selected, participation will involve approximately 3 hours of time: an hour-long audio- and video-recorded individual interview, a 30-45 minute Google Form Questionnaire, and an hour-long audio- and video-recorded focus group. For the focus group, you will be with myself and up to 4 other grade level classmates. You will also be given a written copy of your interview transcripts for your review. The individual interview and focus group will take place in my LiveLesson. Participants will need to be on webcam and use microphones. The sessions will be recorded and only viewed by me, the researcher.

Participation is completely voluntary. [Parent], your decision to allow your child to participate will not affect your or your child's current or future relations with Liberty University, Orion, or Rigel. [Student], if selected, you are free to not answer any question. If you want to be in this study, then tell mee, the researcher. If you don't want to, it's OK to say no. I, the researcher will not be angry. You can say yes now and change your mind later. It's up to you.

Participants will be compensated for participating in this study. At the conclusion of the focus group, participants will receive a $30 Amazon gift card. Any participant who chooses to withdraw from the study after the beginning but before completing all study procedures will receive a prorated Amazon egift card: $10 after the individual interview, $20 after the questionnaire, or $30 after the focus group.

There are many benefits of this research. The participants could gain a better understanding of how they learn, what causes them to stop thinking during a lesson, and what helps them to refocus. This research will also help educators know how to best help students identify important information and what helps them refocus when needed. Society will benefit from the literature with online learning.

Participant identity will remain confidential with the use of pseudonyms. [Student], if you are selected to participate, any individualized responses you provide will not be shared with your teachers or connected to you. All digital data will remain secured on my triple-password locked work computer. Confidentiality cannot be guaranteed in the focus group setting. While discouraged, other members of the focus group may share what was discussed with persons outsides of the group. Any digital or physical data will be destroyed after 5 years.

If your child is ineligible to participate, your answers to these questions today will be destroyed. If your child is selected to participate, these responses will become part of the study materials. I will protect your information as confidential and safeguard it from unauthorized disclosure. I am the only person that will have access to the information shared in today's confidential conversation.

Screening Questions (Answers will be recorded by the researcher. The researcher will offer to send a digital copy via WebMail to the parent/guardian):

Questions for Parent	Questions for Student/Potential Participant
1. What grade is your child in? 2. What is your child's age? 3. Is your child a self-motivated learner? 4. Is your child able to speak and write in English how they feel or their experience? 5. Is your child able to be on webcam and use a microphone in LiveLesson?	1. Are you a self-motivated learner? 2. Are you comfortable with speaking and writing in English about how you feel or your experience? 3. Are you comfortable with being on webcam and using a microphone in LiveLesson?

Do you have any questions?

Appendix F

Child Assent to Participate in a Research Study

What is the name of the study and who is doing the study?
The name of the study is Leveraging Signaling to Prevent Cognitive Disengagement in Virtual Middle School Students, and the person doing the study is Mrs. Mandira Gerrels.

Why is Mrs. Gerrels doing this study?
Mrs. Gerrels wants to know how you identify important information in a lesson, what causes you to stop thinking during a lesson, and what helps you to refocus.

Why am I being asked to be in this study?
You are being asked to be in this study because you are in 7th or 8th grade. You have identified as a self-motivated learner, and you can express how you feel.

If I decide to be in the study, what will happen and how long will it take?
If you decide to be in this study, you will meet with Mrs. Gerrels (one-on-one) for an individual interview in her LiveLesson Classroom for about 1 hour. She will ask you 11 open-ended questions with no right or wrong answers. Next, Mrs. Gerrels will send you a written copy of our dialogue for your review. Then, you will get a Google Form questionnaire with 5 open-ended questions with no right or wrong answers. This should take about 30-45 minutes to complete. After, you will meet with no more than 4 other [Rigel] classmates from your grade level for a small group interview. Your classmates and you will meet with Mrs. Gerrels in her LiveLesson Classroom for about 1 hour as we investigate deeper into how you recognize important information and stay focused.

Do I have to be in this study?
No, you do not have to be in this study. If you want to be in this study, then tell the researcher. If you don't want to, it's OK to say no. The researcher will not be angry. You can say yes now and change your mind later. It's up to you.

What if I have a question?
You can ask questions any time. You can ask now. You can ask later. You can talk to the researcher. If you do not understand something, please ask the researcher to explain it to you again.
Signing your name below means that you want to be in the study.

_____

Signature of Child/Witness Date

Researcher: Mrs. Mandira Gerrels
mgerrels@XXXXX or XXX-XXX-XXXX
Faculty Sponsor: Dr. Carol Gillespie
Cagillespie2@liberty.edu
Liberty University Institutional Review Board
1971 University Blvd, Green Hall 2845, Lynchburg, VA 24515
irb@liberty.edu

Appendix G

Parental Consent Form

Title of the Project: Leveraging Signaling to Prevent Cognitive Disengagement in Virtual Middle School Students
Principal Investigator: Mandira Gerrels, Doctoral Candidate, Liberty University

Invitation to be Part of a Research Study

Your student is invited to participate in a research study. Participants must be in either 7th or 8th grade, identify as self-motivated to start lessons on their own, and be able to express themselves in English. Participants will also need to be comfortable of being on webcam and using a microphone in LiveLesson. Taking part in this research project is voluntary.

Please take time to read this entire form and ask questions before deciding whether to allow your child to take part in this research project.

What is the study about and why are we doing it?

The purpose of the study is to understand the experiences and perceptions of virtual middle school students learning. The research wishes to determine if there are perceived moments when students mentally disconnect from coursework and what helps them reconnect. This study will also investigate what best practice strategies are perceived to help students identify important information in a lesson.

What will participants be asked to do in this study?

If you agree to allow your student to be in this study, I will ask your child to do the following:

1. Participate in a video-recorded one-on-one interview with the researcher (Mrs. Gerrels) in the her LiveLesson Classroom. The interview will consist of 11 open-ended questions posed by the researcher regarding your child's experience with the cognitive disengagement and signaling phenomena. This will take approximately 1 hour.
2. A written transcript of the interview will be provided to the participant via WebMail. The student will be given one week to check for accuracy, make changes, or update their response digitally via WebMail.
3. Once the transcript is confirmed, a Google Form questionnaire will be sent via WebMail to the participant. The questionnaire contains 5 open-ended questions and should take approximately 30-45 minutes. This will investigate perceptions on preferred lesson organization and reflecting on learning process.
4. Participate in a video-recorded focus group with no more than 4 other classmates from this school. The 5 or less participants will meet in Mrs. Gerrels's LiveLesson Classroom, and she will facilitate the meeting. Seven open-ended questions will be asked to dig deeper into how students recognize important information and how mental overload can be prevented. This should take approximately 1 hour.

5. A written transcript of the interview will be provided to the participant via WebMail. The student will be given one week to check for accuracy, make changes, or update their response digitally via WebMail.

How could participants or others benefit from this study?

The direct benefits participants should expect to receive from taking part in this study are gaining a better understanding of how they learn. In particular, participants may gain insights on what causes them to become mentally overload; therefore, this can be prevented in the future. Likewise, students will have a better understanding of which lesson cue helps them find the critical information. These valuable insights can be shared with future teachers to better support them academically or employed by the participants, themselves.

Benefits to society include contributing to the literature on cognitive engagement, preventative measures of cognitive disengagement, and identifying the preferred form of signaling. By describing the first-hand student experiences of mental overload and learning cue preferences, future educators can be best equipped to support virtual scholars.

What risks might participants experience from being in this study?

The expected risks from participating in this study are minimal, which means they are equal to the risks your child would encounter in everyday life.

How will personal information be protected?

The records of this study will be kept private. Published reports will not include any information that will make it possible to identify a subject. Research records will be stored securely, and only the researcher will have access to the records.

- Participant responses will be kept confidential by replacing names with pseudonyms.
- Interviews will be conducted in a location where others will not easily overhear the conversation.
- Confidentiality cannot be guaranteed in focus group settings. While discouraged, other members of the focus group may share what was discussed with persons outside of the group.
- Data collected from your student may be used in future research studies and shared with other researchers. If data collected from your student is reused or shared, any information that could identify your student, if applicable, will be removed beforehand.
- Data will be stored on a password-locked computer in the researcher's personal locked office. Any physical documents will be kept in a locked cabinet also in this office. After five years, all electronic records will be deleted and all hardcopy records will be shredded.
- Recordings will be secured in our school's password-protected virtual classroom for five years until participants have reviewed and confirmed the accuracy of the transcripts and then deleted. The researcher (Mrs. Gerrels) will have access to these recordings.

How will participants be compensated for being part of the study?

Participants will be compensated for participating in this study. At the conclusion of the focus group, participants will receive a $30 Amazon egift card. Any participant who chooses to withdraw from the study after the beginning but before completing all study procedures will receive a prorated Amazon egift card: $10 after the individual interview, $20 after the questionnaire, or $30 after the focus group.

Is study participation voluntary?

Participation in this study is voluntary. Your decision whether to allow your child to participate will not affect your or your child's current or future relations with Liberty University, [Orion], or [Rigel]. If you decide to allow your child to participate, your scholar is free to not answer any question or withdraw at any time without affecting those relationships.

What should be done if a participant wishes to withdraw from the study?

If you choose to withdraw your child from the study or your student chooses to withdraw, please contact the researcher at the email address/phone number included in the next paragraph. Should you choose to withdraw your child or should your student choose to withdraw, data collected from your scholar will be destroyed immediately and will not included in this study. Focus group data will not be destroyed, but your child's contributions to the focus group will not be included in the study if you choose to withdraw your child or your student chooses to withdraw.

Whom do you contact if you have questions or concerns about the study?

The researcher conducting this study is Mandira Gerrels. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at mgerrels@XXXX or XXX-XXX-XXXX. You may also contact the researcher's faculty sponsor, Dr. Carol Gillespie, at cagillespie2@liberty.edu.

Whom do you contact if you have questions about rights as a research participant?

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the IRB. Our physical address is Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA, 24515; our phone number is 434-592-5530, and our email address is irb@liberty.edu.

Disclaimer: The Institutional Review Board (IRB) is tasked with ensuring that human subjects research will be conducted in an ethical manner as defined and required by federal regulations. The topics covered and viewpoints expressed or alluded to by student and faculty researchers are those of the researchers and do not necessarily reflect the official policies or positions of Liberty University.

Your Consent

By signing this document, you are agreeing to allow your child to be in this study. Make sure you understand what the study is about before you sign. You will be given a copy of this document for your records. The researcher will keep a copy with the study records. If you have any questions about the study after you sign this document, you can contact the study team using the information provided above.

I have read and understood the above information. I have asked questions and have received answers. I consent to allow my child to participate in the study.

☐ The researcher has my permission to audio-record and video-record my child as part of participation in this study.

_____

Printed Child's/Student's Name

_____

Parent/Guardian's Signature Date

Appendix H

Individual Interview Research Questions

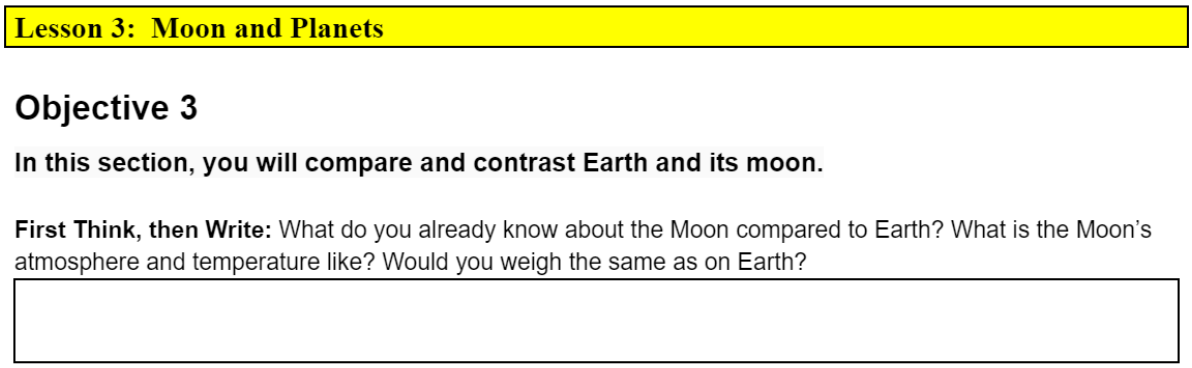
1. Greetings, Scholar! Thank you for speaking with me today. We will be discussing how you learn. There are no right or wrong answers because this is about your experience, so please feel empowered to be honest. Plus, remember that your responses are all confidential meaning that I will not be telling anyone else (like your current teachers or Learning Coaches) about what you share. This is a safe space. I am excited to learn about your story. Let us start with your background. Please tell me about you and about your family.
2. What are some hobbies or activities that you enjoy doing?
    a. Clarifying question: What is your favorite, and why?
3. Let us shift to discussing your school experience. Please tell me about your journey at Rigel thus far.
    a. Follow-up question: How long have you been at Rigel?
    b. Follow-up question: What other types of schooling did you do before Rigel?
    c. Follow-up question: What will your future schooling be like?
4. How do you feel about being a virtual student and learning online? CRQ
    a. Follow-up question: What is your favorite and least favorite class? CRQ
    b. Follow-up question: Describe your typical school day or routine. CRQ
5. Next, I have a two-part question. First, I want you to think about a time when you were really excited or loved a lesson. Describe that day and how it made you feel. SQ1
6. How do you know what information is important in a lesson? SQ2

   a. Follow-up question: Please give me an example of when a teacher helped you identify the important information? SQ3
   b. Follow-up question: Tell me about a time when your Learning Coach helped you complete a lesson. SQ3
7. Second part, I want you to think about a time when learning was complex. Describe that day and how it made you feel. SQ2
8. *Collins Dictionary* (2024) defines disengagement as separating or detaching from something. In your experience, what does disengagement look like, sound like, feel like? CRQ
   a. Follow-up question: what is happening in your mind during disengagement? SQ1
9. Let us go back to thinking about your hobby (from question 2). We know that there are a lot of reasons for having to stop (weather, time, parent says so), but think about a time when it was totally up to you to stop. Explain what happened or why you decided to do something else. SQ1
10. Similarly, there are many reasons to disrupt a school lesson. We are going to focus though on our thinking, specifically. Please give me an example of a lesson when you spaced out or found yourself no longer paying attention? SQ1
    a. Follow-up question: What situations make it challenging to focus? SQ1
    b. Clarifying question: lesson structure or layout SQ1
11. Thank you so much for sharing your experience. I have one more question that will preview the next research steps of the questionnaire and the focus group. In your experience, how do you get back into doing your schoolwork? SQ3

Appendix I

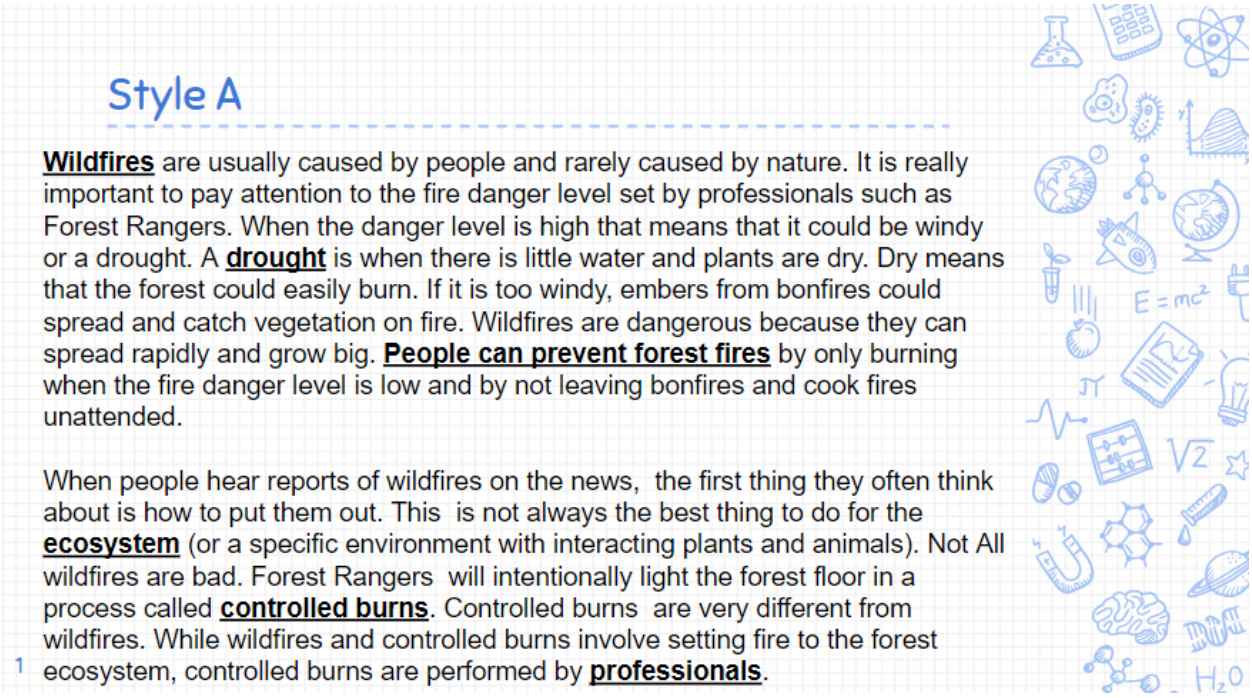
Student Questionnaire Research Questions

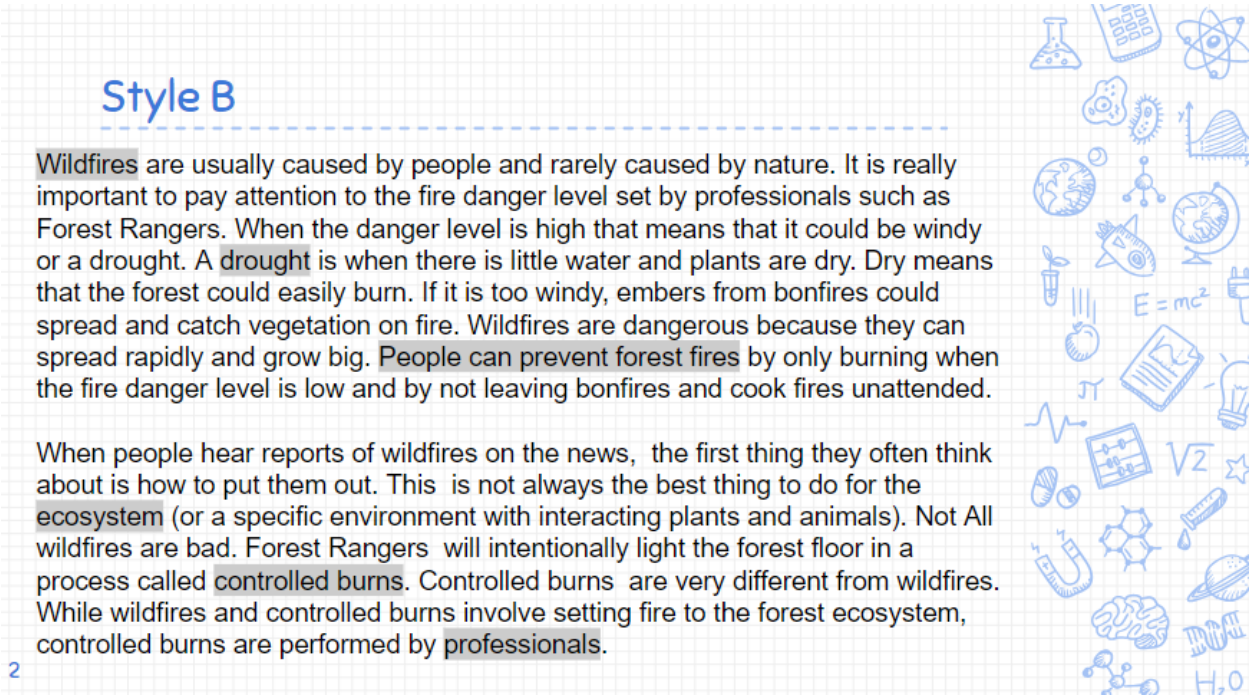
Thank you for taking the time to thoughtfully answer these questions that will explore *how* you learn and *what helps* you learn. There are no right or wrong answers as this is your perceived learning, so please feel empowered to answer honestly and thoughtfully. At the end of the questionnaire, you will have an option to send a copy of your responses to your own email. Otherwise, a copy will be sent to you afterward by Mrs. Gerrels.

1. 

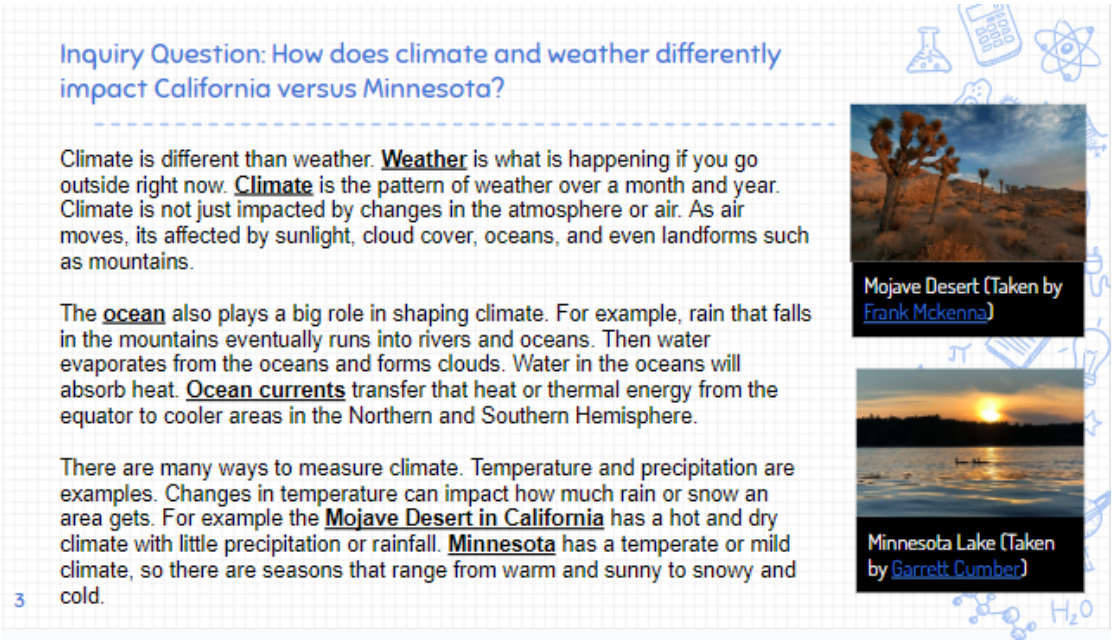
   The question will have the above picture of a typical science lesson guide and the lesson objective. The picture is from a note guide created by the researcher. Explain in detail how you would complete a typical lesson. CRQ

2.





The question will have two pictures (above) of a lesson of the same science topic but in two different formats. The text was created by the researcher. Compare and contrast the two lessons. Which style would help you learn more and why? SQ1

3. 

The question will have a picture of the above lesson with an inquiry question. (Note: The text was created by the researcher. The pictures have free user license from Unsplash.com. The Mojave Desert, California was taken by Frank Mckenna and the Minnesota Lake was taken by Garrett Cumber). Your teacher asked you to help your classmate learn this topic. How would you help your classmate understand the important information? SQ2

4. This question will begin with a video that demonstrates different types of signaling (identified by lettered slides) of the important information. [Script from video: Slide #1 Hi, Scientists! In this question, you will be shown a series of slides with different types of signaling or cues. First, you need to identify the two objects that are important for each picture. Then, you will reflect. What letter of the slide was your favorite and why? Remember the reflection is more important than getting the images correct. You may pause and replay this video as many times as you like. Remember to document how many times you watched the video in the description. Slide #2 Here is the original image. (I

will use to the cursor and read each image aloud: satellite, cowboy hat, airplane, pterodactyl, clock, pine trees, cartoon, fire hydrant, cat, stingray, cherry trees, river, dragonfly, jeep, phonograph, dog, donut, horse, observatory). Slide #3 Style A- Bolding; Which two objects are important? Slide #4 Style B – Highlighting; Which two objects are important? Slide # 5 Style C – Icons; Which two objects are important? Slide #6 – Style D – Blurring; Which two objects are important? Slide #7 Style E – Instructor Pointing; Which two objects are important? Slide #8 Style F – Instructor Arrows; Which two objects are important? Slide #9 – Instructor Circles; Slide #10 – Instructor Voice inflection or emphasis; Which two objects are important? Slide #11 Great job! You may rewatch this video as needed. Please be as detailed as possible in your reflection. Which Slide (Style A-H) was your favorite and why?]

   a. Link to unlisted video (embedded into Google Form): https://watch.screencastify.com/v/iwYj4dLt713A4M5UrdJj
   b. Link to unlisted slideshow: https://bit.ly/QuestionnaireSlideshow (Note: The video and slideshow were created by the researcher).
   c. How do you know what information is important?
   d. What letter of slide was your favorite and why? SQ3

5. Reflect on how you completed this questionnaire. Here are some questions to think about as you provide a thorough explanation of your process. CRQ
   a. **How** did you complete this survey in one sitting or multiple? If multiple, what caused you to stop in between? SQ1
   b. **Who** (if anyone) helped you and how? SQ2
   c. **Where** did you complete this questionnaire? CRQ

d. **What** type of device did you complete this questionnaire on? SQ3

e. **What** else do you wonder or did you think about your learning process? CRQ

Appendix J

Focus Group Research Questions

1. Greetings, Scholars! Thank you all for joining today. I greatly appreciate your time. As we begin, we have a few group norms to review. This is a safe space, and your identity is important. Please use the pseudo names of others. We will respect all ideas because there are no right or wrong answers. We are investigating your personal experiences with disengagement or losing learning focus. Reminder that these conversations are confidential and information here should not be shared elsewhere. Please feel empowered to be honest and speak up. To try our best not to interrupt each other, we will use the hand raise feature. After you share, please lower your hand. Are there questions, comments, or concerns on the norms?
2. Think about when you are completing an online lesson. What causes you to disconnect from completing that work? SQ1
3. How do you know what information is important in a lesson? CRQ
4. You experienced several different types of signaling in the Questionnaire (shows list of examples on the screen). In your opinion, how did these cues impact your learning? SQ3
5. Our brains have a limited capacity to process new information. Explain a time when you felt overloaded with information. CRQ
    a. Follow up: In your experience, how have you reengaged after feeling disconnected? SQ2
6. You have done a great job. We have one more formal question. How can cognitive overload be prevented? SQ3

   a. Follow-up topics: lessons organized, your role, your learning coach's role, your teacher's role CRQ

7. Thank you so much, Scholars! I greatly appreciate your time. Is there any final thoughts or insights on your own learning or what helps you learn that you would like to share? CRQ

Appendix K

Alignment of Methodology Questions to Research Questions

(1) Individual Interview (2) Questionnaire (3) Focus Group

CRQ	**What are the lived experiences of virtual middle school students during cognitive disengagement and signaling?**
1: #4	How do you feel about being a virtual student and learning online?
1: #4a	What is your favorite and least favorite class?
1: #4b	Describe your typical school day or routine.
1: #8	*Collins Dictionary* (2024) defines disengagement as separating or detaching from something. In your experience, what does disengagement look like, sound like, feel like?
2: #1	The question will have the above picture of a typical science lesson guide and the lesson objective. The picture is from a note guide created by the researcher. Explain in detail how you would complete a typical lesson.
2: #5	Reflect on how you completed this questionnaire. Here are some questions to think about as you provide a thorough explanation of your process.
2: #5e	**What** else do you wonder, or did you think about your learning process?
3: #3	How do you know what information is important in a lesson?
3: #5	Our brains have a limited capacity to process new information. Explain a time when you felt overloaded with information.
3: #6a	Follow-up topics: lessons organized, your role, your learning coach's role, your teacher's role
3: #7	Thank you so much, Scholars! I greatly appreciate your time. Is there any final thoughts or insights on your own learning or what helps you learn that you would like to share?

SQ 1	**What are the perceived causes of cognitive disengagement in virtual middle school students?**
1: #5	Next, I have a two-part question. First, I want you to think about a time when you were really excited or loved a lesson. Describe that day and how it made you feel.
1: #8a	What is happening in your mind during disengagement?
1: #9	Let us go back to thinking about your hobby (from question 2). We know that there are a lot of reasons for having to stop (weather, time, parent says so), but think about a time when it was totally up to you to stop. Explain what happened or why you decided to do something else.
1: #10	Similarly, there are many reasons to disrupt a school lesson. We are going to focus though on our thinking, specifically. Please give me an example of a lesson when you spaced out or found yourself no longer paying attention?
1: #10a	What situations make it challenging to focus?
1: #10b	Clarifying question: lesson structure or layout
2: #2	The question will have two pictures (above) of a lesson of the same science topic but in two different formats. The text was created by the researcher. Compare and contrast the two lessons. Which style would help you learn more and why?
2: #5a	**How** did you complete this survey in one sitting or multiple? If multiple, what caused you to stop in between?
2: #5c	**Where** did you complete this questionnaire?
3: #2	Think about when you are completing an online lesson. What causes you to disconnect from completing that work?

SQ2	**How do middle school students describe the influence of signaling on cognitive disengagement in virtual learning?**
1: #6	How do you know what information is important in a lesson?
1: #7	Second part, I want you to think about a time when learning was complex. Describe that day and how it made you feel.
1: #11	Thank you so much for sharing your experience. I have one more question that will preview the next research steps of the questionnaire and the focus group. In your experience, how do you get back into doing your schoolwork?
2: #3	The question will have a picture of the above lesson with an inquiry question. (Note: The text was created by the researcher. The pictures have free user license from Unsplash.com. The Mojave Desert, California was taken by Frank Mckenna and the Minnesota Lake was taken by Garrett Cumber). Your teacher asked you to help your classmate learn this topic. How would you help your classmate understand the important information?
2: #5b	**Who** (if anyone) helped you and how?
3: #5a	In your experience, how have you reengaged after feeling disconnected?

SQ3	**What type of signaling (if any) is perceived by middle school students as the most effective in virtual learning?**
1: #6a	Please give me an example of when a teacher helped you identify the important information?
1: #6b	Tell me about a time when your Learning Coach helped you complete a lesson.
2: #4	What letter of slide was your favorite and why?
2: #5d	**What** type of device did you complete this questionnaire on?
3: #4	You experienced several different types of signaling in the Questionnaire (shows list of examples on the screen). In your opinion, how did these cues impact your learning?
3 #6	You have done a great job. We have one more formal question. How can cognitive overload be prevented?

Appendix L

Participant Demographics

Pseudonym*	Grade	Age	Gender	Identified Race
Aquila	7	13	Female	White
Aries	8	12	Female	Multiracial (Asian/White)
Bootes	7	12	Male	Multiracial (Hispanic/White)
Cassiopeia	8	13	Female	White
Columba	7	12	Female	White
Draco	8	13	Male	Multiracial (Asian/White)
Lupus	7	12	Male	White
Norma	8	14	Female	White
Pegasus	7	12	Male	Multiracial (African American/White)
Phoenix	7	12	Female	White
Pyxis	7	13	Male	White
Taurus	7	12	Male	Multiracial (African American/White)
Tucana	7	12	Male	White
Virgo	8	13	Female	Multiracial (Hispanic/White)
Vulpecula	7	12	Female	White

Note. This table shows the 15 participants and their demographic information.

*Pseudonyms are constellation names that have been assigned randomly to the participants. There is no connection to the participants' real name or other demographically identifiable information.

Appendix M

Quotes to Themes Progression Example

Students Responses:	Primary Codes:	Theme:
Columba: And then my brain doesn't brain or at last it doesn't brain in the way that I want it to.	Brain doesn't Brain	Brain Goes Rogue
Norma: I don't think any teacher could make me engaged my mind wanders everywhere… all the time.	Mind Wanders	
Pegasus: Well as I'm spaced out, I usually picture my head, and I'm usually hitting it with my dog or being a NASCAR driver or flying because sometimes when I grow up, I might think about being a pilot.	Daydreaming	
Aquila: Mainly because it's like 'Atomic Structure Unit Test' so that mainly gives away what we're focusing on.	Resource Signaling: Title	Effective Signals for Virtual Learning
Draco: Because I'm required to highlight keywords.	Student uses Signals	
Tucana: He [Dad/Learning Coach] helps me usually by sometimes he'll give you hints. Like if we're online, he'll move the cursor towards the one.	Other People using Signals	

Appendix N

Codes to Themes Progression Example

Primary Codes	Secondary Codes	Theme
Desire	Internal Factors	The Cognitive Threshold
Goal Driven		
Guilt		
Perfectionism		
Tired		
Trust		
Boring	External Factors	
Distractions (People, Pets, Technology)		
Forced Stop / Family		
Technology Glitch		
Assessment Driven	Resource Signaling	Effective Signaling for Virtual Learning
Bolding / Keywords		
Context Clues / Titles		
Explicit Statements	Teacher / Learning Coach Signaling	
Cursor Pointing		
Arrows / Circles	Student Signaling	
Color-Coordinated Notes		
Highlighting		