Physical Learning Spaces and College Students with ADHD

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By

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DEDICATION

This is dedicated to everyone who carried me on their shoulders so I can succeed in this endeavor. My parents, Uldarico and Genoveva Tijamo, who loved me so much to push me to do the very best in anything I do. My elementary and high school teachers who allowed me to explore my limits and grow. My college professors, especially the ELPS faculty, for imparting their knowledge to me. All my family and friends who continuously gave me encouragement throughout the years.

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TABLE OF CONTENTS

COPYRIGHT ......................................................................................................................... ii
SIGNATURE PAGE .............................................................................................................. iii
ACKNOWLEDGEMENT ........................................................................................................ iv
DEDICATION ....................................................................................................................... v
ABSTRACT .......................................................................................................................... vii
CHAPTER 1. STATEMENT OF THE PROBLEM ................................................................. 1
CHAPTER 2. REVIEW OF LITERATURE ............................................................................ 10
CHAPTER 3. METHODOLOGY .......................................................................................... 42
CHAPTER 4. RESULTS ........................................................................................................ 62
CHAPTER 5. SUMMARY, DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS FOR FUTURE RESEARCH ................................................................. 98
REFERENCES .................................................................................................................... 132
ABSTRACT

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Doctor of Education in Educational Leadership

There is an increasing number of college students with attention deficit hyperactivity disorder (ADHD); however, the academic outcomes for this population are less than optimal. Although these students are offered accommodations in higher education, one area that needs further investigation is whether existing and planned physical instructional spaces facilitate their success. This study explored the impact of physical instructional spaces on the learning experiences of college students with ADHD. Employing an ethnographic case study approach, eighteen college students with ADHD, enrolled in a large, public, four-year university in Southern California were interviewed and classrooms were observed. The findings from this research show that the different features of the physical instructional environment do impact students’ learning
experiences, including their interaction and participation in class, their connections with instructors and fellow students, their mental readiness to learn, and their ability to focus and maintain their attention in class. Although these responses to environmental features may also reflect those of the general student population, the impact to students with ADHD may be magnified due to the added challenge of ADHD symptoms such as inattention, impulsivity, and disorganization. In addition, the findings showed that students with ADHD are diverse in their learning styles and the impact of different environmental features vary among the students. Theoretical contributions and implications to faculty, campus planners, advisors, and students are discussed.
CHAPTER 1. STATEMENT OF THE PROBLEM

As a parent of twin boys diagnosed with attention deficit hyperactivity disorder (ADHD), I am a witness to the academic struggles they go through in elementary and middle school. Their report cards almost uniformly show remarks such as “does not pay attention in class,” “does not show effort,” or something similar. However, in fifth grade both of my boys were fortunate to have teachers who understood the dilemma that students with ADHD face (one of the teachers reported that she has ADHD herself) and thus provided learning environments that accommodated for their disorder. As examples, a space was provided along the back wall of the room for students to walk back and forth to expend their extra energy. Also a piece of Velcro strip glued to the underside of the desk from which tennis balls could be pulled, helped focus one’s attention, according to my son. While these are special interventions and strategies designed to help students with ADHD, it would be unrealistic to expect such specialized accommodations as students progress through middle school, high school, and college.

However, as a college administrator, I wonder whether the learning environments that we offer our students help or hinder the learning experience of students with different learning styles, such as those with ADHD. As campuses construct new spaces or renovate existing ones, it would help campus planners, space designers, and administrators to have evidence-based information regarding learning spaces with potential to benefit a vast majority, if not all, of their student body. This is especially important during tough economic times when there are competing demands on both physical and financial resources of colleges and universities.
ADHD is a condition that is associated with deficits in the executive functioning of the brain and is manifested in hyperactivity, inattention, and impulsivity in individuals (National Institutes of Mental Health [NIMH], 2012). Its effects on children may include poor academic performance, inability to control behavior thus leading to poor social relationships, and low self-esteem (NIMH, 2012). Data show a high percentage of students with ADHD in colleges and universities. In fact, a report by the National Center for Education Statistics (NCES) suggested that in the academic year 2008/09, about 202,000 college students with disabilities were enrolled (unduplicated headcount) in public four-year universities; of these, 23% are reported to have Attention Deficit Disorder (ADD) or ADHD (Raue & Lewis, 2011). According to Wolf (2001), more high school students successfully complete high school and attend college because of special education and other interventions designed to help students with disabilities; thus, colleges and universities should expect an increasing percentage of college students with ADHD on their campuses.

As more students with ADHD enter higher education, it is important to examine whether these students continue to experience difficulties academically in college, and if they do, to explore the factors contributing to these difficulties. Studies show that indeed, college students with ADHD struggle with the academic rigors of higher education. Norwalk, Norvilitis, and Maclean (2009) found that students who manifest higher levels of ADHD symptoms have lower abilities to adjust in college and eventually lead to academic failure. This is not unexpected because students with ADHD have difficulties in the learning strategies and skills considered to be helpful in academic success, such as organizational skills, ability to focus, and sustain attention.
(Norwalk et al., 2009). In addition, a study on college students showed that inattention, instead of hyperactivity, continues as a major factor resulting in poor academic adjustment, decreased career-decision making ability, and poor study skills (Norwalk et al., 2009).

**Research Problem**

Since there is an increasing number of college students with ADHD, and the academic outcomes for this population are less than optimal, higher education institutions need to provide appropriate accommodations for this student population. Typical accommodations that are offered in colleges and universities include providing note takers during classes, course packs offered in accessible media, or extended examination time (National Alliance on Mental Illness, n.d.). However, one area that needs further investigation is whether our existing and planned physical instructional spaces facilitate the success of all students, including those with learning difficulties such as ADHD. Specifically, we need to know how the architectural characteristics of physical learning spaces and design elements within those spaces impact the experiences of college students with ADHD.

The existing literature provides some insight on the impact of physical learning spaces on learners. For example, there are studies that investigated the connection of furniture arrangement, seating position, or seating choices to students’ participation in classes, behavior, or course grades (Sommer, 1967; Levine, O’Neal, Garwood, and McDonald, 1980; Wulf, 1976; Becker, Sommer, Bee, & Oxley, 1973). Other studies examined the effect of lighting, noise, and temperature to the cognitive performance of
students (Knez & Kers, 2000; Knez, 1995; Hygge & Knez, 2001; Knez & Hygge, 2002; Evans, 1979). However, there is no existing study conducted on the effects of the physical learning environment on college students with ADHD.

**Research Purpose**

The purpose of this qualitative study conducted at a large, public university was to explore the impact of physical instructional spaces on the learning experiences of college students with attention deficit hyperactivity disorder (ADHD). The study entailed interviews and classroom observations. The goal of the study was to inform campus planners of the implications of constructions and renovations of learning spaces on students with different learning styles. Specifically, this study has the potential to inform campus administrators and space designers what environmental designs are effective in helping students with learning difficulties achieve academic success as they make decisions on constructing, renovating, and repurposing existing spaces.

The study will also help faculty understand how physical spaces affect the ability of their students to focus and keep their attention on the materials being taught, be able to retain the information being shared, and actively participate in class discussions. Lastly, it will help students recognize factors in the physical environment that could help in their learning process; conversely, it will help students to know what factors in their environment hinder their learning and pre-emptively strategize how to minimize those effects.
Research Question

This study sought to answer the question: How do the different architectural characteristics and design elements of the physical learning environment impact learning experiences as perceived by college students with ADHD?

Theory

This study on the learning experiences of college students with ADHD in the physical learning spaces of a university was guided by the framework of cognitive learning theory, specifically, cognitive load theory. Cognitive learning theory emphasizes the role of the brain and its mental processes in processing information that leads to learning (Schunk, 2012; Sullivan, Johnson, Mercado, & Terry, 2009). This theory uses the information processing model to explain how information is received, processed, and retrieved by the brain. Cognitive learning theory suggests that the brain has a network of sensory registers and a dual-memory system (i.e., short- or working-memory and long-term memory); sensory registers receive information input, transfer it to short-term memory, store it momentarily, and then transfer it to long-term memory. Learning occurs when the brain can retrieve the information from its long-term memory and apply it to new situations (Schunk, 2012). However, attention plays a major role in the input of information to the sensory registers; that is, in order for the sensory registers to properly and efficiently process inputs, the brain needs to be able to focus its attention on relevant stimuli and ignore irrelevant ones (Schunk, 2012). In addition, the demand or cognitive load on the information processing capacity of the brain has to be managed so as to maintain efficient processing of information and learning. There are three categories of cognitive load: (a) intrinsic cognitive load; (b) extraneous cognitive load;
and (c) germane cognitive load (Schunk, 2012). The last two loads, extraneous and germane, can be manipulated. Specifically, we want to minimize any extraneous demands on the information processing capacity of the brain (e.g., loud background auditory noise or too much visual stimuli) and maximize any germane resources (e.g., grouping and presenting relevant information together so the brain can process their relevancy easier) in order to maintain a balanced cognitive load. Thus, I investigated those elements in the physical instructional spaces that create extraneous cognitive load on the information processing of college students with ADHD and I explored those factors that promote germane resources that help facilitate processing for these students. In order to do this, I conducted in-depth interviews of college students with ADHD, seeking to understand their motivations and challenges, their learning experiences in the physical learning spaces of their campus, and their interactions with classmates and teachers within those spaces. I also conducted direct observations of the classrooms that the study participants identified as spaces where they either had good or bad learning experiences.

**Overview of Methodology**

The research design that I used in this study is the ethnographic case study approach. The ethnographic design allowed me to explore and gain in-depth knowledge of the learning experiences of college students with ADHD enrolled in a large public university. The case study approach allowed me to bind my study around a single group (i.e., college students with ADHD in my selected research site) and limited time duration (i.e., during a single semester). I used descriptive analysis to gain a better understanding of the learning experiences of college students with ADHD as a whole. My data
collection instruments included an interview protocol and direct observation of classrooms.

My preliminary data analysis consisted of transcribing the interviews and identifying surfacing concepts that later helped in developing thematic codes used in my in-depth analysis. During the thematic data analysis phase, the early codes that I developed were further analyzed, expanded, or distilled into themes that helped me make meaningful interpretation of the data.

**Limitations/Delimitations/Contributions**

The major limitation of my project is the limited number of student participants due to the bounded design of this study. First, the time required to properly collect, analyze, and interpret the data to finish my dissertation within the doctoral timeframe did not allow for a large number of study participants. Nor did the time allow for any longitudinal study to see if there are changes to the experiences of study participants as they spend more time on campus and adjust to college life. Second, this study was limited to my research site, “California Public University,” and its set of students as opposed to studying several campuses with different characteristics, environment, culture, and sets of students.

Since this is an ethnographic case study, it was delimited by the data source; i.e., I only studied college students with ADHD at this research site and only to the extent of their learning experiences within the physical instructional spaces of this university. The classroom observations were delimited to those spaces identified by the study participants that they perceived to either contribute or obstruct their learning experiences.
This study is contributing to the larger study of ADHD by providing information on the connection of physical learning spaces and ADHD. By exploring what and how different elements of physical learning space help in the cognitive processing of college students with ADHD, campus planners will be able to design spaces that accommodate diverse learning needs, faculty will gain insight on how different spaces can affect the dynamics of student learning, and students will be cognizant of how spaces affect their learning.

**Organization of the Dissertation**

The organization of this dissertation is as follows: (a) Chapter 2, Review of the Literature; (b) Chapter 3, Methodology; (c) Chapter 4, Results; (d) Chapter 5, Summary, Discussion, Implications, and Recommendations for future studies; and (e) References.

Chapter 2 provides a review of existing literature on ADHD, learning theories, and the physical learning environment to frame my research (Macchi and McEvoy, 2012). Chapter 3 provides a detailed discussion of the methodology that I used in this study, the rationale for my research traditions, a description of my research setting, and an explanation for choosing this research site. In Chapter 3, I describe my research sample as well as the data collection instruments and procedures that I used in this study, provide a description of the data analysis method and rationale for choosing this method, and I discuss my role as the researcher, along with my biases and plans for mitigating those biases (Bloomberg and Volpe, 2012). The findings of my interview study are presented in Chapter 4, followed by a discussion of the results and classroom observation findings, conclusions and implications, and recommendations for future
studies in Chapter 5. Lastly, bibliographic information of studies and papers used in this dissertation are listed in the Reference section.
CHAPTER 2. REVIEW OF THE LITERATURE

Definition of ADHD

ADHD as described by the National Institute of Mental Health (NIMH) is “one of the most common childhood brain disorders and can continue through adolescence and adulthood” (NIMH, 2012, p.1). Its symptoms include inattention, hyperactivity, and impulsivity or difficulty controlling behavior and emotional responses (NIMH, 2012). The three symptoms of inattention, hyperactivity, and impulsivity are core characteristics associated with deficits or impairments in the executive function of the brain, according to Understood.org, a program by the National Center for Learning Disabilities (Understood.org, n.d.)

Executive function is a general term used for those complex cognitive processes of the brain that organize information and govern our corresponding responses and actions. Some examples of complex cognitive processes are: modifying behavior based on new information received; shifting and focusing attention; organizing and planning; and processing and recalling information for application to current problems (Elliott, 2003; Morin, n.d.). Those with ADHD have weaknesses with their executive function; thus, they may find themselves having difficulty organizing information and acting on it, filtering out unimportant stimuli and shifting attention, or retrieving information from past learning or experiences (Brown, 2016). Since the core symptoms of ADHD are related to deficits in the executive function of the brain (e.g., organizing and planning, shifting attention, and holding information) it is important to study factors influencing learning, including physical learning spaces.
Persistence of ADHD into Adulthood and Changes in ADHD Symptomatology

While ADHD is commonly diagnosed during childhood, there are indications that the symptoms of ADHD persist into adolescence and adulthood (Norwalk, Norvilitis, & Maclean, 2009; Biederman, Mick, & Faraone, 2000). A study conducted on behalf of the National Institutes of Health estimated that about 4.4% of adult population (ages 18-44) in the United States has ADHD (Kessler et al., 2006). In another randomized study, Faraone and Biederman (2005) estimated adult ADHD prevalence of 2.9% for Narrow ADHD and 16.4% for Broad ADHD. Participants are classified with Narrow ADHD if they reported strong symptoms as defined in the Diagnostic and Statistical Manual of Mental Disorders (4th ed.) or DSM-IV in both childhood and adulthood and broad ADHD if the symptoms reported are closer to prescreening criteria; i.e., criteria that practitioners would use to refer patients for further clinical assessment (Faraone & Biederman, 2005). In addition, there are adults who manifest symptoms of ADHD but have never been diagnosed with the disorder during their childhood (Lewandowski, Lovett, Codding, & Gordon, 2008). These studies imply that ADHD may be more prevalent among adults than reported and thus have implications for institutions of higher education and the workplace (Lewandowski, et al., 2008).

Important too are findings that the degree of severity of ADHD core symptoms (i.e., inattention, hyperactivity, and impulsivity) appears to change with age. A study conducted by Biederman, et al. (2000), assessed participants’ manifestation of ADHD symptoms in categories of inattention, hyperactivity, and impulsivity by age group and compared the results with their symptoms at the onset of diagnosis. The authors
reported that of the three symptoms, inattention persisted more as age progressed and is likely to be the main symptomatic reaction rather than hyperactivity or impulsivity in adults with ADHD (Biederman, et al., 2000).

**ADHD in College**

**Prevalence of ADHD in Post-Secondary Education**

Since ADHD symptoms - particularly inattention - continue into adulthood, it is reasonable to assume ADHD occurs among college students. As mentioned earlier, in a survey conducted by the National Center for Education Statistics or NCES (Raue & Lewis, 2011) for fiscal year 2008/09, of the 202,000 college students with disabilities enrolled in public four-year institutions, 23% have ADD or ADHD. This percentage is expected to increase as more students with ADHD successfully graduate from high school and transition into college (Wolf, 2001). A study conducted by DuPaul, Weyandt, O’Dell, and Varejao (2009) estimated that 2 to 8% of college students reported symptomatology of ADHD while another study on college students in China and the United States estimated 4.4% of American students and 7.8% of Chinese study participants self-reported having ADHD symptoms (Norvilitis, Ingersoll, Zhang, & Jia, 2008). Most currently, a study by Green and Rabiner (2013) on 197 undergraduate students estimated the prevalence of ADHD to range between 3 to 13%. Lastly, similar to the findings of Lewandowski et al. (2008) on adult ADHD, Weyandt, Linterman, and Rice (1995) conducted a study exploring the prevalence of self-reported ADHD symptoms among college students and found about 7% of the participants reported ADHD symptoms as adults, with a fewer percentage reported having symptoms both in childhood and adulthood. The implication of the study, according to the authors, is that
the incidence of ADHD in college students “may be relatively common in college students” (Weyandt et al., 1995, p. 300) because there may be more students who were not previously diagnosed or have not self-identified themselves.

Wolf (2001) explains that the increase in enrollment of students with ADHD in post-secondary institutions is aided by several laws that were put into effect to protect the rights of students with disabilities. The Americans with Disabilities Act (ADA), Individuals with Disabilities Education Act (IDEA) of 1975, and Section 504 of the Rehabilitation Act of 1973 were all enacted to provide equal access to people with disabilities in education and the workplace (Timmons et al., 2010). Specifically, IDEA requires public schools to develop Individualized Education Programs (IEPs) for each disabled child, while Section 504 requires institutions to provide “reasonable accommodation” and “program accessibility” (Timmons et al., 2010, B-2) which include in-school services such as study aids and other supports (Timmons et al., 2010). Wolf (2001) posits that because of the protection afforded by these laws, students with disabilities are now able to access public education and the accommodations afforded these students contribute to the increase of graduation rate of high school students with disabilities since these laws were put into effect.

It should be emphasized that although these laws require active participation of primary and secondary schools in accommodating students with disabilities, higher education students must first need to self-identify themselves as having a disability so the institution can provide access and reasonable accommodation. Consequently, since students with ADHD are not required to inform their institutions of their disorders, the actual prevalence of ADHD in college may be underestimated (DuPaul et al., 2009;
Weyandt & DuPaul, 2006; Norwalk et al., 2009). Thus, with ADHD symptoms persisting into adulthood, the prevalence of ADHD symptoms in college students not formally diagnosed with the disorder, and the possibility of students with ADHD not self-reporting their disorder, there may be more students with ADHD in today’s post-secondary institutions than is being reported.

**Academic Performance of Students with ADHD in College**

Several studies show that college students with ADHD struggle in adjusting and performing academically in college. Norwalk et al. (2009) conducted a study of undergraduate students on the correlation of ADHD symptoms degree of severity, academic adjustment, and performance in college. They reported significant negative correlation between severity of ADHD symptoms and academic adjustment; when students manifest higher levels of ADHD symptoms, their ability to adjust in college decreases (Norwalk et al., 2009). The authors noted that these results are not surprising since prior studies have shown that students with ADHD have manifested academic difficulties, specifically in the areas that require executive functions such as organization, focusing, and sustaining attention (Norwalk et al., 2009). It is also very important to note that of the three key symptoms of ADHD (i.e., inattention, hyperactivity, and impulsivity), “only inattention symptoms, and not hyperactive symptoms, were predictive of lower career decision-making self-efficacy, study skills, and academic adjustment” (Norwalk et al., 2009, p. 256). The authors further posit that there are many distractions in the college environment and much less structure than in primary and secondary education setting. This exacerbates the effects of inattention on
academic performance placing students with ADHD at an “increased risk for failing academically” (Norwalk et al., 2009, p. 256).

Similarly, a study on college adjustment conducted by Rabiner, Anastopoulous, Costello, Hoyle, and Swartzwelder (2008) found that inattention was manifested more among college students with ADHD during their period of adjustment from high school to college, and is the major contributor to poor academic performance of college students with ADHD. Additionally, Blase et al. (2009) conducted a cross-sectional and longitudinal study on students with ADHD and their adjustment in college and reported that as expected, students diagnosed with ADHD are performing lower academically than regular students, and are more likely to get lower grades and have social adjustment difficulties. In addition, the authors reported that the difficulties continue to manifest beyond the students’ initial semester and are likely to persist all through college life. Similar to Norwalk et al., Blase et al. (2009) explain that the college environment is vastly different from junior and high school in that there is a great deal more unstructured time in college where the students’ skills on time management and organization – two areas of executive function where students with ADHD manifest most difficulty – would be greatly needed; in some, greater academic demands and more opportunities for distractions do not help students with ADHD in college (Blase et al., 2009; Norwalk, Norvilitis, and MacLean, 2009; Wolf, 2001).

Lastly, a study conducted by Reaser, Prevatt, Petscher, & Proctor (2007) compared the learning strategies and study skills of students with ADHD, students with learning disabilities, and college students without ADHD or learning disabilities, using the Learning and Study Strategies Inventory (LASSI) which measures attitude,
motivation, time management, anxiety, concentration, information processing, selecting main idea, study aids, self-testing, and test strategies. Their results showed that both the ADHD group and learning disabilities group scored low on motivation, information processing, and self-testing; however, the ADHD group scored lower than the other two groups in time management, concentration, selecting main ideas, and test strategies (Rabiner et al., 2007). This finding is significant because it provides insights into the learning strategies and study skills of these different student groups. It also highlights the learning challenges of students with ADHD in college – motivation, information processing, concentration, selecting main ideas, testing – which are all related to cognitive processes.

**Cognitive Learning Theory**

A general review of learning theory was conducted to better understand the cognitive processing challenges facing students with ADHD. According to Schunk (2012), there are two broad categories of learning theory: (a) behavioral theories and (b) cognitive theories. Behavioral theories state that learning is a function of responses to external stimuli; that is, learning is dependent on “how stimuli are arranged and presented and how responses are reinforced” (Schunk, 2012, p. 22). The learners’ responses to stimuli are influenced by “reinforcement history” (Schunk, 2012, p. 22) or the degree to which individuals were exposed to similar stimuli in the past and their current “developmental status” (Schunk, 2012, p. 22) or what the individuals can do mentally “given his or her present level of development” (Schunk, 2012, p. 22).

On the other hand, cognitive theories emphasize that learning is a function of processes in the brain; i.e., information is mentally processed via “construction,
acquisition, organization, coding, rehearsal, storage in memory, and retrieval or nonretrieval from memory” (Schunk, 2012, p. 22). Although cognitive theories recognize that environment plays a role in the process of learning, it is what the individuals do with the information they receive that are of utmost significance (Schunk, 2012). This is where memory, motivation, and transfer of information play important roles in learning. In cognitive theories, learning occurs when received information is encoded or stored in memories in an organized manner so it can be retrieved later (Schunk, 2012). Motivation influences how much attention will be directed to the information received and how information will be processed (Schunk, 2012). Finally, learning is solidified when processed information is then transferred — “applied in new ways, with new content, or in situations different from where they were acquired” (Schunk, 2012, p. 24), making memory organization and retrieval critical in the cognitive process.

**Information Processing Model**

The neurophysiology of learning under cognitive learning theory uses the information processing model to explain how the brain processes information. This model uses the concepts of sensory registers and a dual-memory system – short-term (or working memory) and long-term memory – and it works as follows: input is received and held momentarily by the sensory registers where it could be discarded or passed on to short-term memory, where it is stored temporarily. The brain then looks for relationships or connections between the new material received and existing information and after doing so, stores the new information in long-term memory for later retrieval (Schunk, 2012).
It is during the input stage to the sensory registers that attention plays an important role in the information processing model. The field of neuroscience explains that sensory inputs (those inputs received via our sense organs, except for smell) are not “sent in the same form in which it was received; rather it is sent as a neutral ‘perception’ of that input” and it is this perception that connects the input to existing information stored in memory in a process called “pattern recognition” (Schunk, 2012, p. 55).

According to Schunk (2012), perception is significant in learning because of the brain’s function of filtering out what it perceives to be unimportant data and filtering in what it perceives to be important. The brain’s filtering function is necessary because our senses receive numerous inputs at any given time; therefore, without this filtering function, it would be impossible to focus and process information. Thus, our ability to pay attention to what we perceive to be important helps in absorbing data received by our senses and processing information (Schunk, 2012). This is particularly important because according to the information processing model, the human brain’s capacity to process information is of limited capacity. Since information processing requires multiple cognitive processes, there is a limited amount of information and a limited duration of time that information can be held in the short-term or working memory; the information would need to be transferred to the long-term memory, rehearsed, and sent back to working memory for application (Schunk, 2012). Thus if the brain receives too much stimuli all at once, or if the brain does not have the ability to filter out unimportant information and focus its attention on what is important, the learner will miss significant incoming stimuli.
Cognitive Load Model

Cognitive load is the demand on the information processing capacity of the brain and has to be managed so as to maintain efficient processing of information and learning (Schunk, 2012). According to researchers, there are three categories of cognitive load: (a) intrinsic cognitive load, (b) extraneous cognitive load, and (c) germane cognitive load (Schunk, 2012; Paas, Renkl, & Sweller, 2003).

Intrinsic cognitive load are those demands on the information processing capacity that are inherent or are in the very nature of the material that is being presented to the learner (Paas et al., 2003). Learning material is considered to have low intrinsic cognitive load if the different elements comprising it can be learned individually and understood on its own without the learner needing to reference other elements external to the material itself (Paas et al., 2003). Conversely, if learning material is part of a package of information and the elements of that package highly interact with each other thus needing to be understood together rather than individually, that material is considered to have high intrinsic cognitive load. Since the loads are intrinsic to the material, Paas et al. (2003) posit that we can only manage this type of load to a limited extent, such as presenting the learning material into segments or omitting some of the interacting elements that otherwise make the lesson materials complicated, without compromising understanding. Eventually though, all the interacting materials, however high the intrinsic cognitive load, will have to be presented together to ensure complete understanding of the material. Again, here is where the dual-memory system aids processing of information. We know that the short-term or working memory has very limited cognitive capacity to process new information. However, the long-term memory...
has the capacity to form schemas, which are “cognitive constructs that incorporate multiple elements of information into a single element with a specific function” (Paas et al., 2003, p. 2). In essence, once pieces of information are stored in long-term memory, these are organized, grouped, and packed into different schemas, much like zipping large files in computers or nesting folder apps in iPhones. These schemas can then be recalled by the long-term memory and transported to the working memory, thus enabling the working memory to process information much larger than its capacity. Automation of this process by the brain further reduces the load on the working memory (Paas et al., 2003; Schunk, 2012).

Extraneous cognitive load occurs when learning material is presented to the learner in such a way that makes the learner exert more mental effort in understanding the material, thus preventing the working memory from acquiring or transporting schemas to the long-term memory (Paas et al., 2003; Schunk, 2012). For example, if a learner has to stop and search for a word definition outside of the presented material, then this creates an extraneous cognitive load on the learner. Paas et al. (2003) point out that extraneous cognitive load is significant to consider when the intrinsic cognitive load is already high, because adding extraneous cognitive load would definitely hinder understanding. For example, if students are learning about chemical reactions, but explanation on acids and bases is not integrated into the learning material, this creates additional extraneous cognitive load.

Germane cognitive load, on the other hand, is the load that is dedicated to the formation of schemas and occurs when the learning material is presented to the learner in a way that enhances understanding of the material (Paas et al., 2003). This occurs
when the working memory is freed up from searching for information because these are already incorporated into the presented material, thus making the working memory available to other processes such as acquisition and transportation of schemas to the long-term memory (Paas et al., 2003).

It is important to understand that the working memory has limited resources; therefore, cognitive load cannot exceed the resources of the working memory. Intrinsic cognitive load is given primary resources by the working memory; any available resources after usage of the intrinsic cognitive load can then be reallocated to deal with either the extraneous or germane loads. Thus, if extraneous cognitive load is reduced, then there are more available resources in working memory that can be used to acquire schemas, automate the schema transport system, or develop more advanced schema thus facilitating improved learning (Paas et al., 2003). To summarize, balancing the cognitive load calls for minimizing the extraneous load, maximizing the germane load, and managing the intrinsic load to improve efficiency of learning (Nguyen & Clark, 2005).

**Cognitive Load Theory and Physical Environment**

In the cognitive load theoretical framework discussed above, three causal factors affect the cognitive load: (a) task characteristics; (b) learner characteristics; and (c) the interaction of task and learner (Choi, Van Merrienboer, & Paas, 2014). These causal factors are assessed by three metrics: (a) mental load which focuses on the characteristics of the task; (b) mental effort which focuses on the amount of resources that learner exerts in processing the task; and (c) performance of the learner (Choi et al., 2014). As suggested by the authors, we can “predict the cognitive load and learning
performance” (Choi et al., 2014, p. 226) of learners by analyzing the task characteristics (e.g., learning math by problem-solving vs. following a worked example), learner characteristics (e.g., beginning math student vs. advanced math student), and the interactions between the two (Choi et al., 2014). In previous cognitive load models, environment was considered to be part of the task characteristics. However in a new model proposed by Choi et al. (2014), it is argued that the physical environment should be separated from task in assessing cognitive load because it presents causal effects on learning outside of the task. For example, loud background noise could deter processing of information because it diverts the attention of the learner from the task at hand or crowded rooms can interfere with learning because of the physiological effect on some learners such as increased blood pressure and discomfort. Choi et al. (2014) state the environment encompasses both task and learner under the assumption that learning will always take place in an environment (i.e., virtual, social, or physical) and the interactions of environment-task, environment-learner, and environment-task-learner affect the cognitive load.

Under this new model, one of the ways cognitive load can be managed is by changing the physical environment. For example, in looking at the environment-task interaction, it might prove helpful to learn subject matter if classes are conducted in a subject-related environment. For the environment-learner interaction, Choi et al. (2014) suggest that novice learners might benefit more in an environment without too much irrelevant detail because they may not be able to separate those irrelevant details from important ones. However, to date, there has been little investigation of the effect of the
physical environment on cognitive load. What do exist are studies of the effect of physical learning environment on physiological, affective, and cognitive performances.

**Physical Learning Environment**

**Definition of Physical Learning Environment**

The concept of learning environment or learning space has evolved both in definition and form. An early definition of learning environment relates to the “interpersonal climate or the organizational structure of a classroom” (Weinstein, 1979, p. 577). Today, learning environment can be more broadly defined as any type of environment where learning can take place whether physically, socially, or virtually. The *Glossary of Education Reform* website by Great Schools Partnership (2013) offers a definition of the learning environment as “the diverse physical locations, contexts, and cultures in which students learn” (Great Schools Partnership, 2013, n.p.). Similarly, learning spaces may mean different things to different people: some would refer to ‘learning space’ generally as where teaching and learning take place while others would define learning space as the actual physical classrooms, laboratories, etc. (Temple, 2008; Johnson and Lomas, 2005).

**General Existing Studies on Physical Learning Environment**

Empirical studies on physical learning environments have evolved over the years. Earlier studies conducted by Sommer (1967), Becker, Sommer, Bee, and Oxley (1973), Wulf (1973), Weinstein (1977), Evans (1979), Stires (1980), and Levine, O’Neal, Garwood, and McDonald (1980) focused on ecology of classrooms or how the different elements within the environment affect student participation, grades, or behavior. The independent variables commonly studied were furniture arrangement,
classroom type, presence or absence of windows, room and class size, seating position, or room ambience. Later studies focused on sensory factors such as the effect of lighting, heat, and noise on cognitive and task performance (Knez & Kers, 2000; Knez, 1995; Hygge & Knez, 2001; Knez & Hygge, 2002). There are also empirical studies on the effects of a restorative environment --- an environment that physically or conceptually provides relief to attention fatigue by not requiring one’s use of voluntary attention --- to attention capacity (Tenessen & Cimprich, 1995; Herzog, Black, Fountaine, & Knotts, 1997; Berto, 2005; Staats, Kievet & Hartig, 2002). More recently, the research literature includes a range of topics including the technological aspects of space, linkage of space to student learning, and evaluation of innovative classroom designs (Brooks, 2011; Oblinger, 2006; Wood, Warwick, & Cox, 2012; Brooks, 2012; Temple, 2008; Ramsden, 2011; Sparrow & Whitmer, 2014; Roberts & Weaver, 2006).

Several empirical studies linking physical environment to student performance are presented here according to the effect of space on the learner. These studies are organized according to the following categories: (a) cognitive effects, (b) physiological effects, and (c) affective effects. However, as noted by Choi et al. (2014), these are not distinct groupings because environment is “multidimensional” and encompasses both learner and task, thus its effects “may be closely intertwined” (p. 231).

**Cognitive effects of the physical learning environment.**

**Cognitive performance.**

Studies were conducted on how cognition is affected by the different elements of the physical space; specifically, these studies looked into the effect of noise, lighting, and heat to long- and short-term memory recall, problem-solving, and productivity of
study subjects (Knez & Kers, 2000; Knez, 1995; Hygge & Knez, 2001; Knez & Hygge, 2002). Knez and Hygge (2002) examined the effect of background noise such as irrelevant speech in the cognitive performance of individuals and found that the subjects’ long-term memory recall of novel text were better in silence versus having irrelevant speech as background noise. The authors believe that this is due to disruption caused by irrelevant speech during the acquisition of information to the brain (or encoding phase of cognition); they called this “divided attention effect” (Knez & Hygge, 2002, p. 716). In essence, the brain’s cognitive resources are not fully allocated to the acquisition of information because the brain is also processing irrelevant information (viz. irrelevant speech) at the same time. Thus, the ability to recall important information decreases. Similarly, Hygge and Knez (2001) found that noise affects attention; that is, attention tasks such as word search gets faster at higher noise levels but the accuracy of finding the right word decreases.

In addition, several studies found that noise levels and/or temperature in rooms affect the performance of either long-term or short-term memory; i.e., long-term memory recall is better in combined effect of low noise conditions and warmer temperature (at 27°C) while short-term memory recall is better at cooler (21°C) than warmer (27°C) temperature (Hygge & Knez, 2001). Lighting was also found to have an effect on cognitive performance. Knez and Hygge (2002) found that long-term memory recall is impaired on subjects exposed to cool-white lighting (4000 K lamp) versus warm-white lighting (3000 K lamp). In addition, Knez and Kers (2000) found that lighting produces emotional effects on subjects in that changing the room light from cool to warm lighting affects the negativity or positivity of subjects’ moods which in turn
affect their cognitive performance on long-term recall and recognition as well as short-term memory recall and problem-solving skills.

**Participation.**

Research has been conducted to explore the elements in classrooms that affect the level of participation by students in their classes. In an early study of classroom ecology in college, Sommer (1967) studied the dynamics of how students are arranged in classrooms and their participation in class by comparing different class sections taught in different types of rooms: seminar-type room, laboratory, and traditional classroom. This quantitative study observed six class sections with 24 students in each section taught by two teaching assistants teaching three sections each. The first two sections were placed in seminar-type rooms and the second two sections were placed in a laboratory with fixed, long, high tables, and laboratory stools. The third two sections were placed in traditional small classrooms with portable chairs arranged in rows and columns; one of the rooms had plenty of windows while the other one had none. In the middle of the semester, the sections switched classrooms and the overall levels of student participation were studied. Sommer (1967) semi-concluded that clear visual contact with the instructor is a major factor in student participation. Specifically, in the seminar rooms where tables were arranged in either square or U-shaped, those students who were seated directly opposite the instructor participated more than those seated at the side tables. The results from the laboratory rooms, where fixed tables were arranged in rows, showed those seated in the center and side front rows participated more than those from the second row and beyond. However, results from the traditional small classrooms yielded conflicting results and the author attributed this to latecomers who did not have
choice of seats; that is, since the rooms were small, the preferred seats were not the front row because these were too close to the instructor. The author proposed that initial choices in seating also play a role in student participation; that is, those whose initial choice is to sit in front of the room (because these are the preferred seats) are more likely to be interested and will participate more while those who are forced to sit in front due to lack of seat choices (e.g., latecomers) will not (Sommer, 1967). This raised the question of whether participation is a function of seating choice, the seating location itself, or a mixture of both (Sommer, 1967).

Two other studies looked into the role of seating choice and its effect on the level of student class participation. Levine, O’Neal, Garwood, and McDonald (1980) conducted a quantitative two-phased study where students were assigned seats during the first phase of the study for four weeks and then were given the opportunity to choose their seats for the next four weeks for the second phase of the study; the instructor was positioned on a raised platform in front of the room. The results indicate that proximity to the front of the room affected significant participation only in the second phase of the study, which supports the notion that seating choice affects participation more than the location itself (Levine, et al., 1980). The other study by Wulf (1976) garnered similar results when comparing two class sections: one class was allowed to choose seats while the other class was assigned seats alphabetically. The results showed that class participation was significantly higher in the front and center of the room, or the “action zone” (Wulf, 1976, p. 2) for the choice class while there were no such significant results in the assigned class (Wulf, 1976). Further, when students in the assigned class were queried as to their seating preference if given a chance, those students who had been
actively participating in the class and were high achievers preferred to have sat in the action zone (Wulf, 1976). A quantitative study conducted by Becker, Sommer, Bee, and Oxley (1973) analyzed whether class sizes and furniture arrangement affect the amount of student participation. Their findings showed that neither class size nor furniture arrangement produced significant results; instead, their results seemed to indicate that the manner by which instructors taught the classes seemed to have more of an effect on class participation (Becker et al., 1973). These were mainly observed in the laboratory setting where students had more mobility and instructors were able to walk around and interact more with students (Becker et al., 1973). These studies seemed to indicate that clear visual contact and access to the instructor are factors affecting students’ participation and students choose seats according to the level of their interest and motivation to pay attention in class; i.e., those who are high-achievers tend to sit where they have visual proximity and access to the instructor.

**Student grades.**

Studies were conducted to figure out whether there is a connection between seating choice and students’ grades. Stires (1980) conducted a comparative study on the impact of seating choice between one class whose students were allowed to choose their seating positions (choice class) versus another class whose students were seated alphabetically (no-choice class). This study sought to test the environmental hypothesis (i.e., seating position has a causal effect on grades) and self-selection hypothesis (i.e., good and interested students choose seats that are front and center of the room) (Stires, 1980). The results showed that the test scores of those in the choice class were significantly higher than those in the no-choice class and there was significant variability
between the scores of those seated in the middle versus those seated at the sides both in choice and no-choice classes. However, there was no significant variability between choice and no-choice classes when looking at the scores of front-back and middle-side, which seemed to support the environmental hypothesis; that is, seating position does affect the grades of students whether they chose the seats or not (Stires, 1980). But similar studies conducted by Wulf (1976) and Levine et al. (1980) provided contradictory results. Their studies showed significant variability on scores of those seated in the front versus back in the choice class, but not in the no-choice class which seem to support the self-selection hypothesis; that is, those students who tend to receive good grades choose seats in front and center of the room and that seating position, by itself, does not have causal effect on grades. However, whether environmental or self-selection hypothesis, having direct visual contact and access to both the instructor and learning material decreases the extraneous load on cognition, because there is less disrupting stimuli, and therefore less demand on students’ attention.

**Physiological effects of the physical learning environment.**

Some studies focused on the effect of physical learning environment on the physiology of students and whether physiological responses affected their ability to learn. Evans (1979) conducted a comparative study of college students in crowded and uncrowded classrooms and found that students in the crowded classroom made more errors than those in the uncrowded classroom when tasks grew more complex. The author hypothesized that this was due to increased levels of stress, blood pressure, and pulse rate brought about by crowded situations (Evans, 1979). In addition, the crowded room students performed less optimally in a group cooperation task where they needed
to formulate a group strategy to win a game based on recurring patterns of the game. This was attributed to inability of reallocating adequate attention to recognize patterns and properly perform the task due to increased stress levels (Evans, 1979). Drawing on the cognitive load theory, it could be assumed that as individuals’ stress levels increase, the amount of extraneous cognitive load increases which compromises the brain’s ability to process and recall information, thus leading to increased errors on tasks that require more cognitive processing.

**Affective effects of the physical learning environment.**

Weinstein (1979) conducted a meta-analysis of several studies on the impact of instructional spaces on student behavior, attitudes, and achievement; specifically, variables such as seating position, classroom design and furniture arrangement, class size, or noise were analyzed for correlations on knowledge retention, grade improvement, or class participation. Weinstein (1979) concluded that although physical environment, in general, did not have a direct effect on school achievement, it did have an effect on “non-achievement behaviors and attitudes” (p. 598). For example, crowded rooms produced “dissatisfaction, decreased social interaction, and increased aggression” while satisfactory rooms were “associated with better attendance, greater participation, and more positive attitudes toward the class, the instructor, and classmates” (Weinstein, 1979, p. 598). Although later studies do find connection between learning space and school achievement, Weinstein’s argument is still significant because, according to the cognitive learning theory, motivation plays an important role in learning since it directs how much attention the brain will provide to the information received which will then affect learning (Schunk, 2012). Thus, if students’ behavior and attitudes are positive
because of satisfactory learning environments, there is greater possibility that learning and achievement will occur (Weinstein, 1979). This was echoed decades later by Temple (2008) in another meta-analysis of learning spaces studies in higher education, specifically in connecting learning spaces to effective teaching and learning, and concluded that space designs should consider the “social underpinnings of learning” and create “welcoming and flexible spaces” (p. 238) that would promote learning.

Another empirical study of interest that relates to the affective effect of space was conducted by Weinstein (1977) to find out whether minor changes in the physical space would produce changes in the behavior of school-age children. The classroom modifications included rearrangement and addition of some furniture, re-painting of some areas, and general attractiveness of the spaces (Weinstein, 1977). Results showed that those areas which students avoided were utilized more often after the spaces were made more accommodating. For example, organizing shelves were added in the science area to eliminate clutter and ease of finding lab materials; raised platforms and carrels were added in the reading area to make it conducive for individual reading; and a general attractive atmosphere induced students to venture to other parts of the room (Weinstein, 1977). Based on these results, Weinstein offered that teachers should be cognizant of the importance of designing their spaces that are congruent with their curriculum (Weinstein, 1977).

Finally, several studies explored the effect of environment in restoring attention capacity after fatigue based on attention restoration theory (ART). According to this theory, attention or mental fatigue occurs when the brain uses much of its energy towards directed attention (viz. our mental voluntary ability to focus attention and
control emotions). Attention fatigue can lead to difficulties in concentration, problem solving, emotional control, and cognitive performance (Berto, 2005; Staats, Kieviet, & Hartig, 2002; Tennessen & Cimprich, 1995; Herzog, Black, Fountaine, & Knotts, 1997). This theory posits that voluntary attention is “effortful and can be tiring, whereas involuntary attention is effortless and allows the attentional system to rest and recover” (Berto, 2005, p. 249); thus, exposure to surroundings that allow individuals to use involuntary or effortless attention will help restore attention capacity (Berto, 2005; Staats et al., 2002; Tennessen & Cimprich, 1995; Herzog et al., 1997). These studies found that nature or natural elements in the environment have restorative qualities on attention capacity and help improve cognitive performance (Berto, 2005; Staats et al., 2002; Tennessen & Cimprich, 1995; Herzog et al., 1997). Therefore, an environment that does not impose extraneous load (e.g., space elements that do not require voluntary attention) allows the working memory to focus on important task or stimuli, thus facilitating cognition processing and improving cognitive performance.

These empirical studies provide evidence that physical environments affect learners either cognitively, physiologically, or affectively. These studies show that environmental stimuli (e.g., irrelevant noise or lighting) as well as inadequate sightline and access to the instructor and learning materials create extraneous load. Similarly, environmental factors such as temperature and over-crowding affect the physiology of learners (e.g., increased stress and blood pressure) which, in turn, affect their cognition ability because of the working memory’s inability to ignore such negative stimuli. Lastly, the affective influence of satisfactory surroundings or positive ambience of space
affects learners’ motivation and “willingness to invest mental effort and consequently on learning” (Choi et al., 2014, p. 233).

**Existing Studies on Physical Learning Environment and ADHD**

The majority of literature on physical learning environment and ADHD focus on classroom interventions that help school-age children with ADHD. These interventions include arranging the classroom in traditional row-seating pattern (this is considered to be very structured and predictable for the students) and placing students with ADHD in front and near the teacher’s desk so they would be less distracted allowing the teacher to provide immediate feedback to the student (Carbone, 2011; Reiber and McLaughlin, 2004). Other interventions include teaching in closed (with walls and doors) rather than open classrooms; removing distracting features of the classroom; moving students with ADHD away from distracting areas such as windows and doors; providing additional desks (or carrels) for students to move to when given a task that requires more attention; having flexible furniture that accommodates easy transition of different pedagogical methods; installing overhead projectors for strong visual impact; and using colors in the rooms and novel learning materials to catch the students’ attention (Carbone, 2011; Reiber and McLaughlin, 2004). Trout, Lienemann, Reid, and Epstein (2007) assessed common non-medical classroom interventions and found that some auditory distractors such as music resulted in increased cognitive performance in school children with ADHD. Interestingly, they found that performance in reading and math for school children with ADHD did not vary in either traditional closed (with walls and door) and open classrooms (Trout et al., 2007).
The majority of empirical studies on ADHD focus on the effect of pharmacological stimulants, clinical studies on attention, or evaluation of self-management strategies. Although there are existing research on ADHD and physical learning environment, those are limited in number and are focused on school-age children, not college students. However, even though these studies do not pertain specifically to college students, some of those studies are still presented here to serve as reference point on the discussion of the effect of physical spaces on college students with ADHD.

One study focused on the effect of group activities on the cognitive performance of school-age children with ADHD; specifically, it explored the effect of independent, small groups, and whole class group work on their on-task behavior during both instructional and testing periods (Hart, Massetti, Fabiano, Pariseau, and Pelham, 2011). The findings showed that during the instructional period, students stayed on-task more in small group work versus independent seat work or whole class group work; however, during the testing period, the small group setting produced less accurate performance than either independent seat work or whole class group work which suggests that although small group settings might help students with ADHD during instruction, it has the reverse effect during testing (Hart et al., 2011). The authors posit that this may be due to teachers giving more structure and guidance during the instructional period in a small group setting such as scaffolding the learning materials, instructions, and activities in order to better capture the children's attention (Hart et al., 2011).

Other studies evaluated the effectiveness of dynamic seating and use of therapy furniture in improving the academic performance and behavior of school-age children
with ADHD. Pfeiffer, Henry, Miller, and Witherell (2008) found that the use of Disc ‘O’ Sit Cushion increased the attention capacity of second-grade students to assigned tasks as well as problem-solving tasks. The authors reason that children with sensory-processing disorders such as those with ADHD have less capacity to filter sensory information and thus have difficulty allocating sufficient attention to significant stimuli (Pfeiffer et al., 2008). However, they state that proprioceptive (or deep pressure) and vestibular (movement) feedback improve attention by increasing arousal of attention; hence, the effectiveness of the therapy cushion in increasing attention (Pfeiffer et al., 2008). Similarly, Schilling, Washington, Billingsley, and Deitz (2003) found that therapy balls improved in-seat behavior and legible word production in school-age children.

Natural and green spaces were also evaluated as intervention tools in helping children with ADHD. Taylor and Kuo (2011) conducted a survey of 421 parents of children with ADHD to find out whether routine exposures to green spaces helped reduced ADHD symptoms. Green spaces are defined as places with either big trees and grass or open grass area. Their findings showed that children who routinely played in green spaces had milder symptoms compared to those who mainly played in built environments (Taylor and Kuo, 2011). Another study compared children with ADHD in natural and built settings in the Netherlands; the natural setting was an open space of a wooded area while the built setting was an open square in town (van den Berg & van den Berg, 2010). Results showed that children performed better on concentration tasks in the woods than in town (van den Berg & van den Berg, 2010).
Other studies focused on the effect of noise on the cognitive performance of school-age children with ADHD. Soderlund, Sikstrom, and Smart (2007) studied and compared the effect of white noise on recall performance of children with ADHD and those without ADHD. They found that white noise improved the cognitive performance of the children with ADHD but had a negative effect on non-ADHD children (Soderlund et al., 2007). The authors explained that this is due to stochastic resonance (SR) which states that a certain level of noise may help cognition. The Moderate Brain Arousal (MBA) model suggests that “noise in the environment introduces internal noise into the neural system” (Soderlund et al., 2007, p. 844) and that “the peak of the SR curve depends on dopamine level, so that participants with low dopamine levels (ADHD) require more noise for optimal cognitive performance compared to controls” (Soderlund et al., 2007, p. 844). Another study analyzed the effect of white noise on off-task behavior, item completion task, and accuracy test on students with ADHD on medication (Cook, Bradley-Johnson, & Johnson, 2014). Results showed that off-task behavior significantly decreased using a combination of headphones and white noise as opposed to just headphones; however, it did not have an effect on either the completion or accuracy tasks (Cook et al., 2014). It is interesting to note that this finding on students with ADHD (e.g., white noise) has contraindication on non-ADHD students.

**Current Discussions on Physical Learning Environment**

The types of formal physical learning spaces that we see on campuses today vary tremendously. Learning spaces include traditional classrooms, lecture halls, laboratories, and Active Learning Classroom (ALC) or Next Generation Learning Space. Traditional classrooms are usually equipped with rows of tab arm chairs or desks and
chairs facing forward, usually a black- or white-board mounted in front of the room, and a desk or podium situated in front for the instructor (Painter et al., 2013). Lecture halls are usually large, auditorium-style rooms that can seat a higher number of students than traditional classrooms. These often have tiered flooring so that those seated in the back can have clear sightlines to the front where instructors usually lecture (Painter et al., 2013). Smart or “technology-infused” (Painter et al., 2013, p. 8) classrooms are traditional-style classrooms that are equipped with digital projectors, projection screens, and computer or laptop connections. These rooms may also have DVD/VCR connections, internet capability, and computer-equipped instructor podiums (Painter et al., 2013). Laboratories vary in design depending on the discipline being taught. For example, science wet labs would typically have fixed furniture and specialized equipment. Computer labs are normally equipped with rectangular tables with computers or laptop connections assigned for each student; these types of classrooms are ideal for hands-on courses or training. The “Active Learning Classroom” or “Next Generation Learning Space” (Painter et al., 2013, p. 9; Sparrow and Whitmer, 2014, p. 311) are spaces that usually have moveable furniture (e.g., wheeled tables and chairs, mobile whiteboards), changeable furniture (e.g., hide-away tables that can fold or hide computer screens for a flatter surface area), and are technology-enhanced with digital projectors, easily accessible ports and electrical outlets, internet connections, projectors, or other new learning technology (Painter et al., 2013; Sparrow and Whitmer, 2014). The flexible design of the rooms allows for diverse teaching modes, ability to work in small groups, and increase engagement and interaction between instructor and students (Painter et al., 2013; Sparrow and Whitmer, 2014).
The current literature on learning spaces ranges from technical and detailed analysis of the various aspects of space – “architecture, space design, pedagogy, staff and student needs, and stakeholder involvement in the design process” (Wilson & Randall, 2012, p. 2) – to linking space and learning as well as teaching, integration of informal and formal learning spaces, and application of innovative space designs (Wilson & Randall, 2012). Fisher (2005) discussed the research methods used over the years to measure the effectiveness of learning spaces. According to Fisher (2005), post-occupancy evaluations tend to focus on the technical details of space; however, there is an increasing trend in linking pedagogy and space thus evidence-based research is on the rise. Examples of evidence-based research are quantitative approaches that measure student test scores related to space improvements and qualitative approaches such as the Organisation for Economic Co-Operation and Development (OECD) Programme on Educational Building (PEB) compendium of exemplary educational facilities which highlight those facilities whose space design, use, and management best align to educational needs (Fisher, 2005). Other experts who also contributed to the space research conversation such as Boys, Melhuish, and Wilson (2014) who provided guidelines on developing research methods on learning spaces and student engagement, and Montgomery (2008) who provided insights about space management.

Growing, too, is the conversation on the infusion of technology in learning spaces. Sparrow and Whitmer (2014) provided guidance on navigating face-to-face, online, and blended learning and argue that learning theories should guide decisions on space planning, because such learning theories “all include the interaction of students with the material, the instructor, and other learners” (Sparrow and Whitmer, 2014, p.
Fraser (2014) argues for assessing the effectiveness of non-traditional classrooms such as Next Generation Learning Spaces with regards to “supporting excellent teaching practices and successful student outcomes” (p. 333) in order to determine whether such spaces do improve student learning. One such study compared the performance of students taught in a traditional classroom versus those in an active learning classroom (ALC) using the same course, taught by the same instructor, and similar student demographics; the only difference was the average ACT scores of those that met in the traditional classroom were statistically significantly higher than those in the ALC room (Brooks, 2011). However, even though it was predicted that those students in the traditional classroom would get higher course grade than those in ALC room because the former have higher ACT scores as a proxy metric to their academic ability, the results of the study found no difference in the average course grade between students in the two rooms. The researcher argues that this is evidence that ALC has a positive effect on student learning (Brooks, 2011).

Gaps in the Literature

The studies on learning spaces covered a broad range of topics and are representative of a variety of different perspectives; some have explored the architectural aspects of space, some have approached the studies from the pedagogical viewpoint, and others have approached it from space design and evaluation perspective (Brooks, 2012). Early studies of the physical learning environment evolved around classroom ecology and how these predict student outcomes such as those studying the effect of seating position, seating choice, or furniture arrangement on student participation, behavior, or grades. Other studies analyzed the different elements (e.g., lighting, noise, ambience,
etc.) and their effect on the cognitive performance of students. Others looked into the physiological effect of space on student outcomes, such as over-crowding, room density, or the absence of windows.

Later, as technology use increased and spread into the classrooms, laboratories, and other physical learning environments, studies were conducted comparing student outcomes between traditional rooms versus technology-infused classrooms while other studies looked into the different innovative uses of these spaces for teaching (Wilson and Randall, 2012). Many of these studies provided case studies of new furniture design or latest technology and how these are incorporated into innovative curriculums to enhance teaching and learning (Brooks, 2012). There are also studies on space design which often are evaluative in nature (e.g., post-occupancy evaluation) and usually measured by satisfaction metrics of students and faculty occupying the spaces (Roberts and Weaver, 2006; Painter et al., 2013; Boys, Melhuish, and Wilson, 2014; Zandvliet, 2013).

Most of the empirical studies are quantitatively researched where aspects of the environment are held as independent variables and the effect on the learners are dependent variables. In addition, these were focused on the generalizability of their findings and therefore were conducted on samples of general student population, not students with deficits in attention or difficulties in controlling their executive functions. Lastly, studies conducted specifically on ADHD and the physical learning environment were focused on school-age children. Findings from most of these studies, such as use of therapy ball furniture or classroom intervention strategies, do not have direct applicability to college students in large university setting.
Thus, the present study focused on college students with ADHD to explore how and to what extent the existing findings apply specifically to their learning experiences. In addition, this study explored how the concepts of cognitive load can be applied to enhance the learning experiences of college students with ADHD within the learning spaces of a university. Specifically, this study analyzed whether there are attributes in the physical learning environment that contributed (germane cognitive load) or obstructed (extraneous cognitive load) the cognitive processes involved in learning for students with ADHD. It was anticipated that there would be practical and theoretical implications from this study. Practically, it provided information to campus planners and administrators on optimal physical learning spaces for different learning styles, information for faculty on how spaces can be used to maximize learning for students with ADHD, and helped students with ADHD recognize those environmental factors that help or hinder their cognition ability so they can navigate and adjust their learning strategies. Theoretically, the findings of this study contributed to the influence of physical learning spaces on cognitive load, an area of investigation that is worthy of study.
CHAPTER 3. METHODOLOGY

Research Purpose

The purpose of this qualitative study was to explore the learning experiences of college students with ADHD in the physical instructional spaces of a large, public, four-year university in Southern California. The study was conducted from the students’ perspectives by asking them, via face-to-face interviews, to share their thoughts and experiences in their classrooms. The goal of the study was to inform campus planners of the implications of constructions and renovations of physical learning spaces on students who have cognitive difficulties. The study will also help faculty understand how physical spaces affect the ability of their students to focus and keep their attention on the materials being taught, be able to retain the information being shared, and actively participate in class discussions. Lastly, it will help students recognize factors in the physical environment that could help in their learning process; conversely, it will help students to know what factors in their environment hinder their learning and pre-emptively strategize how to minimize those effects.

Research Question

The main research question that guided this study was: How do the different architectural characteristics and design elements of the physical learning environment impact learning experiences as perceived by college students with ADHD?

Chapter Organization

This chapter provides information regarding the following: (a) the research tradition that was utilized in this study, (b) the research setting where the study was conducted and rationale for site selection, (c) data sources, research participant criteria,
and sampling strategy, (d) data collection instruments, (e) data collection procedures, (f) description of data analysis procedure, and (g) discussion of my role as researcher, articulation of my beliefs, biases, and assumptions, and how I mitigated these in this study.

**Research Design**

This research was conducted using the ethnographic case study approach. Ethnography is a research tradition that systematically studies a group, specifically its social and cultural traits, behavior, and other observable and patterned characteristics it exhibits as a group (Creswell, 1996). The orienting principle of ethnography is to study in-depth the group’s culture by conducting interviews, observations, and examining the various artifacts related to the group (Creswell, 1996). In this research tradition, the researcher interprets data obtained from her or his observations of the study participants after a prolonged period of study either via direct observations or interviews from a sociological perspective (Creswell, 1996). There are several underlying assumptions in ethnography. First, although human behavior varies widely depending on culture, experience, and social environment, behaviors are “locally specific” (Schram, 2006, p. 68) in that those who share common culture, experiences, and social environment exhibit behavioral patterns that can be observed (Schram, 2006). Second, these observations can be conducted by “experiencing” – personally observing and involving oneself in the study group’s lives and activities – or by “inquiring” from them “about their experiences and the meanings they ascribe to them” (Schram, 2006, p. 68). Third, in order to properly interpret the data that one obtains from the group, one must first understand the reasons why such behaviors are exhibited. The resulting interpretation is a product of
the mutual agreement between researcher and participants on the meaning of those behaviors (Schram, 2006). And last, since ethnographic studies are conducted at a certain period of the participants’ lives, the resulting interpretation will only be a representative of that snapshot in time and from that specific perspective, thus will never be an “exhaustive, absolute description of anything” (Schram, 2006, p. 68). With these assumptions in mind, the final product of an ethnographic study will be a “cultural portrait of the group that incorporates participants’ views [emic] and the researcher’s views [etic]” (Bloomberg and Volpe, 2012, p. 32).

Case studies are intensive analyses and detailed descriptions of a single subject of study (or case) or multiple cases within a bounded system (Merriam, 2009; Creswell, 1996). A bounded system means that the research is conducted within a specified scope or limit of a case. Case studies require that the researcher conduct in-depth data collection involving multiple sources of information rich in context” (Creswell, 1996, p. 61), which includes interviews, observations, and review of documents. The case study in this present research was particularistic in its approach and bounded in terms of the study participants, time, and place; that is, the research topic is the particular learning experiences of a group of college students who have ADHD symptoms, to be interviewed during one semester, within the context of select physical instructional spaces of a large, public four-year university in Southern California (Merriam, 2009).

I chose the ethnographic case study research design because this combined approach provided me with deeper understanding of this particular group of college students’ perceptions of the physical learning environment. Schram (2006) emphasized the importance of linking the research approach to the research questions; the
ethnographic research tradition allowed me to focus on exploring the experiences of college students who share the trait of being diagnosed with ADHD. And given the small size of my research, the case study approach provided manageability of data collection and analysis while at the same time giving me the opportunity to observe the physical learning spaces that the study participants identified as having contributed or obstructed their respective learning experiences.

Research Setting

I conducted my research at “California Public University (CPU),” a large, public, four-year university located in Southern California. It sits on 356-acres of land with more than 20 instructional buildings and halls. CPU has roughly about 40,000 students, which translates to approximately 32,000 full-time equivalent students (FTES) enrolled during the Fall 2014 semester. According to the Fall 2014 statistics posted by the College Portrait of Undergraduate Education, the three major race compositions of this university’s student demographics are Hispanics (42%), Whites (24%), and Asians (11%) which closely mirror the demographics of Los Angeles, the city that this university is situated in, as reported in the U.S. Census Bureau’s QuickFacts website (2010). CPU has about 4,000 faculty and staff and offers a total of 150 baccalaureate, graduate, and teaching degrees in its eight colleges. It started as a college in the 1950s and has grown steadily over the years.

CPU’s funding comes largely from state appropriations and tuition fees; however, state funding has been decreasing over the last few years due to competing demands on state resources. At the same time, the university is experiencing significant enrollment growth, particularly in the first-time freshman population. Just in the past
year, total unduplicated headcount increased from approximately 38,000 to 40,000. However, the university is unlikely to receive capital funding to construct new buildings; thus, it is imperative that the university be strategic and effective in its use and reuse of existing spaces.

**Site Selection**

I selected this campus as the site of my study for several reasons: (a) diverse student characteristics and demographics of this university; (b) it is a large, public, four-year urban university in Southern California; (c) access to this site through my network of professional connections (Miles & Huberman, 1994); and (d) its disability resources center. As stated earlier, the student demographics from this university are representative of the local and regional communities surrounding the campus and are very diverse. According to a special report prepared for the university by its Institutional Research department (CPU, 2014), the freshmen population has high likelihood of belonging to traditionally underserved racial and ethnic groups (American Indian/Alaskan Native, Native Hawaiian/Pacific Islander, African American/Black, and Latina/o), be first-generation college students, and speak a second language. In addition, their self-perception evaluation showed that only about half of students considered themselves above average on academic ability. These students also have higher likelihood of graduating from non-traditional public schools and needing remediation for mathematics, English, and writing. Thus, the research site offered many opportunities to recruit study participants who could provide varying perspectives on the learning experiences of college students.
Another factor in choosing CPU is its active disability resources center and the possibility of connecting to students with ADHD or attention deficit disorder (ADD). My initial contact with the Center’s director included identifying myself as a doctoral student in an Ed.D. program and providing my professional credentials and connections to the campus. I provided similar introduction and background information to the student participants in my study.

**Data Sources**

The main source of data for this study were matriculated college students with ADHD or ADD. The main method of data collection was one-on-one interviews, ranging from 35 minutes to one hour in length. To triangulate data collected from the interviews, additional data were collected from direction observations of instructional spaces at the research site. There were two sets of direct observations: pre- and post-interviews. The purpose of conducting classroom observations before the interviews was to collect data through the lens of this study’s conceptual framework and supporting literature, without bias of information collected from the interviews. The purpose of conducting classroom observations after the interviews was to confirm data collected from the interviews and whether these connected with my earlier observations, thus triangulating all my collected data and providing this study with information from different perspectives. Both interviews and direct classroom observations are recommended data collection procedures in ethnographic and case studies.
Population and Sample Size

Participants

To conduct my data collection in a large university such as CPU with about 40,000 students enrolled, I applied sampling strategies and narrowed down my study participants to college students identified as having ADHD or ADD. Miles and Huberman (1994) offered a typology of the different sampling strategies that are available for qualitative research such as criterion strategy and opportunistic or networking sampling strategy. In using criterion strategy, the researcher delimits the case participants to the criteria set by the researcher to ensure that it aligns to the research topic, research purpose, and research questions. Opportunistic or network sampling strategy takes advantage of the researcher’s affiliation to the research site in order to gain access to study participants (Miles & Huberman, 1994).

The sampling strategy that I used was a combination of criterion and opportunistic or network strategies (Miles & Huberman, 1994). The criteria in selecting the research participants were matriculation at my selected research site and identification as having ADHD or ADD. Under opportunistic or network strategy, I used my professional affiliation with the research site to enlist the aid of the director of the disability resources center, who serves as the access gatekeeper to students with disabilities in this research site, in contacting potential study participants. Specifically, I asked the director’s help in communicating my recruitment intentions to them. This was conducted by forwarding my recruitment email to students with ADHD or ADD who were registered at the disability resources center database. The contents of the email research invitation was pre-approved by the director of this disability resources center.
The email invited college students with ADHD to participate in a research study that explores the effects of physical instructional spaces such as classrooms, on the learning experiences of college students with ADHD. The email requested interested students to contact me either via email or the office phone number given in the email; it also indicated that a $15 campus card would be given at the conclusion of the interviews as a token of appreciation for participating in this study. In addition, I obtained permission from the campus’ student involvement center to post flyers and distribute post cards in allowed areas on campus.

The email was sent out to 374 students registered in the disability resources center database as having ADHD or ADD. The sample size was eighteen participants. This number was small enough to be a manageable qualitative research sample, but sufficiently large enough to gain understanding of the learning experiences of students with ADHD at the research site (Creswell, 1996).

In any study, there are ethical issues that researchers need to be aware of at each research stage. Kvale and Brinkman (2009) stated that these ethical issues need to be reflected in the researchers’ protocol (p. 63). Since I interviewed college students with ADHD, I was very vigilant in protecting their identities by making sure that I not only provided pseudonyms to my study participants but also provided an 11-character code as a double-barrier protection to their identities.

**Classrooms**

Observations are defined as taking systematic notes of everything that you absorb through your senses (Glesne, 2011). For the pre-interview classroom observations, the research site offered 6,419 total class sections, of which there were
4,162 lecture class sections offered in 365 classrooms on campus. The sample size of the pre-interview observations was nine and represented different classroom sizes and course disciplines (e.g., humanities, social sciences, etc.) in order to have diverse but representative data that were independent from my participants’ perspectives. The post-interview classroom observations were conducted in several rooms from a list of rooms identified by my study participants where they either had positive or negative learning experience; this latter group of observations were guided by the information the study participants provided. Faculty permissions were obtained prior to conducting any classroom observations. Since my research goal was to identify the factors in the physical learning environment that contributed or inhibited the learning experiences of college students with ADHD, the observations notes were coded into two groups: (a) elements in the spaces that create extraneous load to cognition; and (b) elements that create germane cognitive load. The physical learning space observations were two-phased, pre- and post-interview classroom observations.

**Data Collection Instruments**

**Instrument Identification**

The instruments I used in my data collection were a semi-structured interview protocol and direct observations, as suggested by the ethnographic and case study design. The ethnographic design calls for an orderly recording of observations and interviews with the subjects of a study (Spindler & Spindler, 1989). The case study design calls for in-depth observation of a specific case, group of people with a common and binding element such as a study of college students with ADHD (Glesne, 2011).

**Instrument Description and Rationale for Use**
Interview protocol.

In this study, the interview protocol was semi-structured in format; i.e., there was a prepared set of main questions framed around the research topic with follow-up questions that allowed the participants to expand on their initial responses (Bernard, 1994; Glesne, 2011). Semi-structured interview is recommended “when you won’t get more than one chance to interview someone” (Bernard, 1994, p. 209). Since I conducted only one interview per participant, having a semi-structured interview method allowed me to explore their responses deeper in order to gain clear understanding of their thoughts and perceptions about physical learning spaces.

There were about 40 main questions in my interview protocol, which were guided by the literature review, research question, and purpose. Since I was interested in exploring the perceptions of college students with ADHD about learning spaces in a public, four-year, large university, the main questions focused on the students’ thoughts and opinions about classrooms where they attended classes on campus. Follow-up questions were asked, if necessary, in order for me to explore or better understand the context of their responses to the main questions.

Observation.

The observation protocol was a record of (a) physical attributes of the room such as classroom size, shape, furniture arrangement, etc.; and (b) sensory factors such as lighting, sightline, temperature, etc. (Table 1). Included, too, were observations made when classes were in session, recorded at ten-minute intervals, such as how students oriented themselves in the space and interactions between instructors and students.
### Table 1. Classroom Observation Record Form

<table>
<thead>
<tr>
<th>Date:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Room:</td>
<td></td>
</tr>
<tr>
<td>Course:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Setting</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room type</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td></td>
</tr>
<tr>
<td>Shape</td>
<td></td>
</tr>
<tr>
<td>Floor seating</td>
<td></td>
</tr>
<tr>
<td>Furniture</td>
<td></td>
</tr>
<tr>
<td>Furniture arrangement</td>
<td></td>
</tr>
<tr>
<td>Windows</td>
<td></td>
</tr>
<tr>
<td>Doors/access</td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sensory factors</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td></td>
</tr>
<tr>
<td>Acoustics</td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td></td>
</tr>
<tr>
<td>Sightlines</td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participants</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Who are in the room?</td>
<td></td>
</tr>
<tr>
<td>How many?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Context</th>
<th>Observations @ 10 minute intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe what’s going on at 10-minute intervals</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activities and Interactions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Is there &quot;activity of interest&quot; or situation? What is it?</td>
<td></td>
</tr>
<tr>
<td>How did the students respond/behave?</td>
<td></td>
</tr>
<tr>
<td>How do the students interact in the room and with one another?</td>
<td></td>
</tr>
<tr>
<td>Are there connections between students and space?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency and Duration</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>When did the &quot;situation&quot; begin?</td>
<td></td>
</tr>
<tr>
<td>How long did it last?</td>
<td></td>
</tr>
<tr>
<td>Is it recurring or unique?</td>
<td></td>
</tr>
<tr>
<td>If recurring, how frequent?</td>
<td></td>
</tr>
<tr>
<td>What are the events that led to it?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subtle Factors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Are there informal activities happening that’s not part of the lesson plan?</td>
<td></td>
</tr>
<tr>
<td>Are there unplanned activities?</td>
<td></td>
</tr>
<tr>
<td>Are non-verbal communications occurring between faculty and students? What?</td>
<td></td>
</tr>
<tr>
<td>Are non-verbal communications occurring between students? What?</td>
<td></td>
</tr>
<tr>
<td>How do participants get attention?</td>
<td></td>
</tr>
<tr>
<td>How much do they fidget?</td>
<td></td>
</tr>
<tr>
<td>How much do they move around?</td>
<td></td>
</tr>
<tr>
<td>How do participants physically place themselves in the setting?</td>
<td></td>
</tr>
</tbody>
</table>
Data Collection Procedures

Pre-Interview Classroom Observations

Prior to interviewing any study participants, I conducted direct observations of nine (9) different lecture classrooms in Fall 2015. These rooms were chosen using the following criteria: (a) academic disciplines of the courses taught in the rooms; (b) academic levels of the courses taught in the rooms; and (c) seating capacity of the rooms. First, to ensure that various academic disciplines were represented in these observations, the following courses were chosen: religious studies and sociology from humanities; geography from social sciences; mathematics from formal sciences; and economics from the professional disciplines. Next, the list was narrowed down to the 100-level classes of these courses because of higher likelihood of freshmen and sophomore enrollment in these courses, with the assumption that this student population would most likely be transitioning into the college culture and be facing more challenges adjusting to the rigors of higher education (Rabiner et al., 2008). Finally, the list of rooms to be observed was further narrowed down by choosing those 100-level courses that were being taught in both large- and regular-seat station rooms, with the exception of college algebra where three rooms were picked to include a small-seat station room (Table 2). For example, *Introduction to Human Geography* classes were observed in both 42- and 125-seating capacity rooms. This provided opportunity to observe differences of interaction in similar classes taught in various classroom sizes.
Table 2. List of Classrooms Observed Pre-Interviews

<table>
<thead>
<tr>
<th>Subject Catalog</th>
<th>Title</th>
<th>Course Credit</th>
<th>Unit</th>
<th>Component</th>
<th>Location</th>
<th>Station Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 160</td>
<td>MICROECON PRIN</td>
<td>3</td>
<td>LEC</td>
<td>R1</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>ECON 160</td>
<td>MICROECON PRIN</td>
<td>3</td>
<td>LEC</td>
<td>R2</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>GEOG 107</td>
<td>INTRO HUMAN GEOG</td>
<td>3</td>
<td>LEC</td>
<td>R3</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>GEOG 107</td>
<td>INTRO HUMAN GEOG</td>
<td>3</td>
<td>LEC</td>
<td>R4</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>MATH 102</td>
<td>COLLEGE ALGEBRA</td>
<td>3</td>
<td>LEC</td>
<td>R5</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>MATH 102</td>
<td>COLLEGE ALGEBRA</td>
<td>3</td>
<td>LEC</td>
<td>R6</td>
<td>121</td>
<td></td>
</tr>
<tr>
<td>MATH 102</td>
<td>COLLEGE ALGEBRA</td>
<td>3</td>
<td>LEC</td>
<td>R7</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>R S  150</td>
<td>WORLD RELIGIONS</td>
<td>3</td>
<td>LEC</td>
<td>R8</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>SOC  150</td>
<td>INTRO SOCIOLOGY</td>
<td>3</td>
<td>LEC</td>
<td>R9</td>
<td>231</td>
<td></td>
</tr>
</tbody>
</table>

After identifying the rooms to be observed, permissions to observe their classes was obtained from the respective instructors. In each classroom observation, I arrived early and positioned myself usually in the back and to the side of the rooms in order to observe the whole classroom unobtrusively.

Noted, too, was how students physically placed themselves in the classrooms (e.g., which general area of the room were filled up first, general seating tendencies of the students) as well as other descriptors of the room such as displayed materials in the room, flow of foot traffic, possible sources of distractions, etc. Then, observations were recorded at 10-minute intervals from the start to the end of each class. A laptop was used to record all observations.

**Interviews**

There were eighteen study participants interviewed and each interview was 35-60 minutes long. Due to the sensitivity of ADHD as a subject matter and to provide confidentiality, the interviews were conducted closed-door in a private office on-campus. This site was chosen because it: (1) was a convenient location for the participants; (2) allowed little to no interruption or distraction; and (3) was relatively
quiet so as not to interfere with the recording of the interview. The study participants were given consent forms to read and sign; verbalized, too, were the key points of the consent form such as the study participants’ voluntary role in this research, their right to withdraw from the study, and the steps that I took to ensure that their information remain confidential. None of the participants declined, thus interviews commenced after the consent forms were signed.

The interview questions were grouped into four sets. The first set focused on basic information about the participants such as their current student level (i.e., freshman, sophomore, etc.) and their major studies. To confirm ADHD or ADD symptomatology, participants were asked when they (or their parents or guardians) became aware that the participants were displaying symptoms of ADHD or ADD.

The second set of questions was about the learning environment. Specifically, participants were asked to identify a classroom that they liked and another one that they disliked and their reasons. Participants were asked to describe the rooms with emphasis on the physical (e.g., room size, shape, furniture, etc.) and sensory (lighting, acoustics, temperature, etc.) attributes and how these affected their learning experiences. They were also asked if there were any factors in the rooms that distracted them from their class lessons, as well as those factors that brought their attention back to the class lessons. Additionally, the students were asked to provide thoughts on what they would add, remove, or change in the rooms to make their learning experience better.

The third set of questions focused on their thoughts about different types of classrooms and furniture arrangements --- referred to as “traditional” and “non-traditional” classrooms --- as well as the presence of technology in classrooms.
Specifically, participants were asked whether any features provided distraction, encouraged participation, affected communication, or affected their ability to see, hear or understand the instructors and other students.

Finally, the fourth set of questions asked the participants how they would design a classroom to fit their learning and/or recommendations they would provide to the University President to help college students with ADHD. For this last set of questions, the first two participants were asked only the design question; the rest of the participants were asked both questions. Immediately after the interviews were concluded, the participants were given $15 campus gift cards as a token of appreciation for their participation in the study.

The participants were each assigned a pseudonym as well as an 11-character code to ensure that their identification was not connected to the data. There was one list of participants’ initials and their assigned pseudonym and another list of pseudonyms and the 11-character codes; the two lists were kept separately from each other and in different locations.

**Post-Interview Classroom Observations**

The interview protocol included asking the participants to identify instructional rooms on campus that they liked or had positive learning experience as well as those they disliked or had negative learning experience and the corresponding classes they took in those classrooms. Fifteen of the eighteen participants provided specific rooms while three participants provided categories of rooms (i.e., standard classrooms and small classrooms). Of the fifteen participants, one student identified two rooms that she liked, a second student identified two rooms that he disliked, and a third student
identified only a room that she disliked. In addition, there were four specific classrooms that elicited differing opinions from nine of the participants; that is, three of these classrooms had a student each liking and disliking them and one classroom had two students each liking and disliking it (one student disliked two of these classrooms). Thus, there were 24 rooms specifically identified by participants.

Of the 24 identified rooms, two were computer labs and one was an activity room; these were excluded from the post-interview observation list. In addition, two of the classrooms from the list were included in the pre-interview observations, thus were also excluded from the post-interview observation list. Also excluded were eight classrooms from the older buildings on campus since these were built decades ago when academic discussions were not yet fully focused on the impact of space on student learning. Thus, the focus of the post-interview observations were three identified classrooms in the two newest buildings on campus because it is possible that these were designed with impact on student learning in mind. Included, too, in the post-interview observations were three rooms adjacent to each other in the science building to understand why two rooms were disliked and one liked, when these rooms seemed to be similar to each other in size and shape.

Finally, as mentioned earlier, there were college algebra classes that were observed pre-interviews in three different classrooms: one in a 121-seat stations room, one in a 60-seat stations room, and one in a 38-seat stations room. The 38-seat classroom was observed again post-interview to see whether the student-teacher interaction observed earlier in this room was replicated in a different class with a different instructor, to control for the instructor’s teaching style and experience. The
class observed in this 38-seat room post-interview was pre-calculus instead of college
algebra because there was no college algebra lecture classes taught in the room during
the semester that post-interview observations were conducted.

The 38-seat room with a pre-calculus class was the only in-class observation held
post-interview. All other rooms were observed without any classes in session. For these
observations, a modified observation protocol was used. These observations served to
triangulate the data collected from the interviews.

Data Analysis Strategy

Preliminary Data Analysis

In order to ensure that my data collection was productive, Glesne (2011) suggests
that data analysis should be conducted concurrently with data collection because doing
so would allow the researcher to reflect on the data as it develops. Reflection can be
done by memo writing or keeping a reflective field log. As suggested by Glesne (2011),
reflexivity files record “observations, thoughts, and questions on how the researcher and
research procedures interact with and influence research participants and vice versa” (p.
190). The goals during this preliminary scan of data were to identify emerging issues
and concepts and, if necessary, reformulate questions to further refine this research.

Thematic data analysis

After reviewing the transcriptions and observation data, these were analyzed to
see if there were any surfacing “themes, patterns, or issues” (Bloomberg & Volpe, 2012,
p. 137). Using my conceptual framework, the data analysis began with the development
of conceptual categories that connected to my research question (Bloomberg & Volpe,
2012). Descriptors were then developed for each of the categories. Then, a second read
of the transcriptions was conducted and codes were assigned and analyzed for surfacing
themes. This iterative process of reviewing data, recoding, and re-analyzing continued until all data had been culled and any concepts and themes that surfaced were checked and cross-checked (Bloomberg & Volpe, 2012).

**Interpretation**

Analysis involves the interpretation of themes or patterns that surface from the data. Bloomberg and Volpe (2012) state that interpretation “is about the meaning derived from a comparison of the findings of the study with information gleaned from the related literature and previous research” (p. 179). Accordingly, the interpretations of this study were guided by the existing body of knowledge on physical learning environment, ADHD, and cognitive load theory to provide framework on how research results contribute to the larger academic dialogue.

**Researcher Roles**

My primary roles in this study were as a scholar, researcher, and university administrator. As a scholar, I studied the existing body of research on the relationship between physical spaces and learning, and how these connect to students with ADHD. In addition, I learned from my participants, and gained in-depth knowledge of their opinions, ideas, and experiences related to the research topic (Glesne, 2011). As a researcher, I designed how this study was conducted, decided the study participant criteria, developed research protocol(s), conducted data collection and analysis, and interpreted results. As a university administrator, I actively looked for applicability of the research results for campus planners, faculty, and students in colleges and universities. Lastly, I brought into this study the perspectives of a mother of twins who were diagnosed with ADHD, taking into account those factors that either helped or
hindered them in their studies, and questioned the applicability of those experiences to this study. These were the different lenses that I used to understand the experiences of my study participants.

**Researcher/Research Effects**

As a researcher, I was cognizant of the fact that I was bringing into this study my own preconceived ideas or biases; however, as Watt (2007) pointed out, these should be considered as assets instead of liabilities as long as I kept these biases in perspective. My embodiments that may have effects on this study, as defined by Glesne (2011), were my age and gender. As a middle-aged woman interviewing college students who potentially would be so much younger than I am, I may be viewed as a “mother” figure; this may help or hinder the data collection process depending on positivity or negativity that mother figures have on the participants. My position, which Glesne (2011) defined as both ascribed and achieved characteristics of the researcher (e.g., institutional affiliation), is that of a university administrator whose responsibility is ensuring that the resources entrusted by the students and the state to the university are used both efficiently and effectively; thus, my bias would be looking at the data through the fiscal lens of serving both current and future generation of students.

**Mitigation Strategies**

To mitigate any possible biases that I may have on this study, I actively kept a reflective journal that allowed me to articulate my thoughts, questions, or doubts about the study (Carlson, 2010). Articulating my biases in the journal helped me reflect on whether these biases were getting in the way of my conducting the research (Watt,
2007). I triangulated my data collection procedure through both interview and site observation in order to get a clearer picture of the research results.
CHAPTER 4. RESULTS

The purpose of this study was to explore the perspectives of college students with ADHD about their learning experiences in the physical instructional spaces of a large, public, four-year university. The goal of the study was multi-fold: (a) inform campus planners of the impact of various architectural and design elements on students who have cognitive difficulties; (b) help faculty understand the diverse effects of physical spaces on students’ ability to focus and engage in class; and (c) help students recognize factors in the physical environment that could help or hinder their learning so they can strategize how to incorporate those factors that help, and conversely minimize those factors that hinder their learning.

The theoretical framework of this study is cognitive load theory, where cognitive load is defined as the demand on the information processing capacity of the brain; i.e., the effort needed by the working memory to process information and store it to the long-term memory (Schunk, 2012). There are three types of cognitive loads: intrinsic, extraneous, and germane. The combination of these three loads cannot exceed the resources of the working memory (Paas et al., 2003; Schunk, 2012). Thus, it is important to balance the three cognitive loads; i.e., minimize extraneous load, maximize germane load, and manage intrinsic load to improve learning efficiency (Nguyen & Clark, 2005). Relating these three cognitive loads to the environment, Choi et al. (2014) suggested that the interactions between environment-task, environment-task-learner, and environment-learner all affect cognitive load. This study explored, via one-on-one interviews, the interactions between environment-learner to understand the factors that either (a) reduce extraneous cognitive load or promote germane cognitive load in classrooms identified by participants that they liked or had positive learning experience;
or (b) increase extraneous cognitive load in classrooms participants disliked or had negative learning experience.

Participants

Eighteen college students were interviewed for this study. All of them responded from the email invitation that was sent on my behalf by the director of CPU’s disabilities resources center to students who registered with the center as having ADHD or ADD. There were twelve female and six male participants with ages ranging between 18-35 years old. The majority of the participants were 20-25 years old (n=13), while others were 18-20 years old (n=2) and 30-35 years old (n=3) (Table 3). The interview protocol did not specifically ask participants their ages but this information was indirectly gleaned from the interviews. For example, those students who mentioned they were first time freshmen were coded in the 18-20 years old bracket; those who were in their junior or senior year were coded in the 20-25 years old bracket; those who explicitly stated their age such as “in 2008 I was listening to NPR, I was about 27 years old…” or “I’m 31” were coded in the appropriate age bracket.

Even though the study participants were recruited from the email sent to students registered at the center as having diagnosis of ADHD or ADD, my interview protocol included a question on how and when students became aware of their ADHD or ADD. This question was included to confirm their diagnoses and eligibility to be participants in this study. The responses uniformly included descriptions of their symptoms which allowed for this information to be collected as data (Table 3). Commonly reported symptoms were difficulty paying attention, trouble focusing, and getting distracted easily. One participant reported having hyperactivity symptoms in early childhood, two
Table 3: Study Participants Characteristics

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Gender</th>
<th>Symptoms/Problems</th>
<th>Co-Diagnosis</th>
<th>Early</th>
<th>Teens</th>
<th>Late</th>
<th>Intervention</th>
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<td></td>
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<td>Uninterested</td>
<td>Anxiety</td>
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<tr>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
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</tr>
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</tr>
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<td>Medication</td>
</tr>
<tr>
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</tr>
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<td>Medication</td>
</tr>
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<td>Difficulty focusing</td>
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<td>✓</td>
<td></td>
<td>Medication</td>
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<td>Depression</td>
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<td></td>
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<td>Medication</td>
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<td></td>
<td>Difficulty focusing</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>P18</td>
<td>30-35</td>
<td>Male</td>
<td>Difficulty finishing work</td>
<td>-</td>
<td></td>
<td>✓</td>
<td></td>
<td>Medication</td>
</tr>
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</table>

reported being forgetful and disorganized in grade school through high school, and three explicitly reported having struggled academically. Most were diagnosed with ADHD or ADD either during grade school or in their early teens (n=11); others at later years (n=7). Of the group diagnosed in later years, some reported that they were diagnosed late due to parental denial or cultural stigma of the diagnosis (n=3), while others either were not aware or did not have enough information regarding ADHD/ADD to seek diagnosis (n=4). In addition, some participants were co-diagnosed with depression,
obsessive-compulsive disorder, and anxiety (n=4); three of these were from the group who were diagnosed in later years. The majority of the study participants were on some form of medication at the time of the interviews (n=12) and others reported availing themselves of other resources such as special classes, IEP, or educational therapies either currently or in the past (n=5).

**Data Analysis**

I personally transcribed the interviews after each was conducted. This allowed me to simultaneously review the interviews, ensure the accuracy of transcriptions, and maintain confidentiality of data (Glesne, 2011). The interviews were not transcribed verbatim: expressions such as “like,” “uhmm,” “you know,” etc. and other non-verbal cues such as laughter were not included in the transcripts to ease transcription since these were not deemed relevant to this study. Finally, I took reflective notes after the interviews to serve as permanent records of my thoughts and observations of the participants. After all analyses were completed and vetted with my dissertation chair, the interviews and all identifying information were destroyed.

After transcribing the interviews in a word processing software, these were converted to spreadsheet software files for ease of coding. The initial spreadsheet files were two-columned tables: the first column contained the participants’ pseudonyms and the second column listed out their responses.

As initial coding, another column was added and labeled “Load” and the responses were coded based on the conceptual framework of cognitive load theory. Each response was coded whether it was extraneous or germane cognitive load: if the response related to unnecessary mental processing of information by the participants,
then it was coded as extraneous cognitive load; if the response related to enabling
participants to process information, then it was coded as germane cognitive load. For
example, if a study participant discussed how the use of a document camera by
instructors to work on a math problem helped understand the lesson, then this was coded
as germane cognitive load; if a study participant discussed how cleanliness of the
classroom made the space feel welcoming, then this was coded as a reduction to
extraneous cognitive load; and if a study participant stated that the room was “freezing,”
then it was coded as an increase in extraneous cognitive load.

Next, the responses were further analyzed for any surfacing “themes, patterns, or
issues” (Bloomberg & Volpe, 2012, p. 137). These were coded using key words or key
phrases derived from the responses, forming the first set of codes or memo codes; these
were entered in a fourth column labeled “Memo Codes.” Interrelated memo codes were
grouped together into conceptual categories that connect to the research question,
forming the second set of codes or meta codes; these were entered in a fifth column
labeled “Meta Codes” next to corresponding memo code cells (Bloomberg & Volpe,
2012). Finally, interrelated meta codes were further distilled down to mega codes and
entered into a sixth column labeled “Mega Codes” next to respective meta code cells.
This iterative process of reviewing data, recoding, and re-analyzing continued until all
data had been culled and surfacing concepts and themes were checked and cross-
checked (Bloomberg & Volpe, 2012). These codes were used as headings and
subheadings for the findings chapter of this dissertation (Bloomberg & Volpe, 2012).

As mentioned previously, the interview protocol was semi-structured to ensure
that study questions were addressed but still allow the researcher to explore, and study
participants to expand on the responses, as needed. The main areas of study included the following: (a) identification of classrooms that study participants liked or where they perceived to have positive learning experience and their reasons; (b) identification of classrooms that study participants disliked or where they perceived to have negative learning experience and their reasons; (c) their thoughts on traditional and non-traditional types of classrooms; (d) their thoughts on different architectural and sensory elements in the rooms such as windows, furniture, lighting, acoustics, or temperature; (e) their thoughts on the use of technology in classrooms. And then finally a “catch-all” question meant to capture their final thoughts on learning environment in case they had ideas that were not captured during the interviews.

**Interview Results**

The results of these interviews are presented here as follows: (i) environmental features with positive impact on study participants; (ii) environmental features with negative impact on study participants; (iii) environmental features with split impact on study participants (there were specific features that some students identified as having contributed positively to their learning experiences while other students identified the reverse); and (iv) subjects’ perception of technology use in classrooms.

**Environmental Features with Positive Impact on Study Participants**

The study participants provided reasons why they liked or felt certain classrooms had a positive impact on their learning; these reasons are later analyzed in the discussion section to explore whether these reduce extraneous cognitive load or promote germane cognitive load on the students.
From participants’ description of classrooms they liked, three features of those classrooms emerged as recurring themes: (a) features that allowed interaction among students and promoted class participation (n=10 students); (b) features that allowed instructors to have the flexibility to move around and accessibility to answer questions on a more individualized basis (n=9 students); and (c) features that made the environment feel more “open” and conducive to learning and allowed the participants to momentarily rest their minds (n=8 students).

**Interaction and Participation**

Some participants preferred spaces where they had opportunity to interact with other students and participate in class discussions (n=10 students). In these classrooms, participants liked that it was possible to connect with other students because of the “intimate atmosphere,” and that in such rooms it was easier to “work in groups because it wasn’t like there was a hundred students” in the room. The ability to collaborate with other students by working in small groups was echoed by two students who liked the computer laboratories (capacity of 24-30 stations) where they took statistics lab classes. They reported that the peer support system that formed around their seating arrangements in the computer laboratories helped them keep track of their classes, in addition to having the ability to easily turn to their neighbors to work on class exercises together.

Yes, we’re all in just a row like this. So there’s just 1, 2, 3, 4 and I’m the third seat...and we have a little study group and it’s comprised of the most strange people that I didn’t imagine all four of us to be friends almost. But somehow, we tried to stay on the same page, we have a group message on texting. And it really helps because sometimes one would say something like “oh, I forgot about that,” and we’ll remind each other. Or they’ll say “how did you do on this?” and I’ll say “oh I got 90%” and they’re “oh, good job!” They encourage you to do best. You work together and somehow it benefits us.
Similarly, the smaller class size in a television studio (class capacity of 10-20 students) allowed for small groups to explore different learning materials and kept students continuously engaged.

You’re learning as a group but then you could also learn as a small group and have three people looking at this one camera and taking turns because there are four cameras; it’s not like forty kids on two cameras.

Since the enrollment in these classes was lower, it was easier for study participants to become familiar with their fellow students and be comfortable to participate in class discussions, thus helping them stay engaged in their classes.

…it’s easy to connect and when we shared personal experiences in that class (we still do), it’s just a lot easier to discuss it with people we already know, whom I’ve talked to. I’ve heard pretty much everybody speak in that class so I don’t feel nervous about what they’re going to say. I pretty much know how they are going to respond to something.

One study participant remarked that a small classroom (27-35 seat stations) provided less distractions, helped him keep track of class activities, and helped to “keep me involved enough where I wouldn’t lose focus or look away or lose myself in something else.” Conversely, another study participant favored a larger classroom (78 seat stations) because it allowed him to “interact with multiple people.” At first glance, this student’s statement seemed to contradict those of the other participants in terms of class size favored, but he further explained that they worked in smaller groups which helped him “make new friends, interact with new people you would normally not have interacted with.” He also acknowledged that “if the room is even slightly larger, then it would no longer be beneficial…there’s just enough space that if you need help, you could get it; any more, then the teacher’s no longer able to help individual students as well.” Thus, the ability to work in intimate settings — either in smaller classrooms or
smaller groups — allowed students to interact with one another, which some participants considered as beneficial to their learning. Specifically, these allowed them to gain different perspectives, which helped them understand their lessons better. Another participant stated:

I feel that I only would think the whole class has one opinion and then when I hear people talk, I didn’t expect that to be said because I judge them (but not on purpose); like that person didn’t look like they know what they’re talking about. But then they start saying something and I’m like “wow, that person really knows what it feels like to do this, this, and this.” So I feel that group discussions are really important in classes that have anything to do with social issues… I feel that the more voices I get to hear, the better.

**Instructor Mobility, Accessibility, and Proximity**

Some participants preferred spaces that allowed instructors the ability to move around the room, be easily accessible to students, or be in close proximity to students to answer questions and give guidance (n=9 students). One participant remarked that in her statistics lab classroom, unlike “standard” classrooms where it was hard to get individual attention from instructors, the desk arrangement allowed the instructor to move around the classroom and interact with students or provide immediate help when students were working on exercises or problems.

It’s mostly the environment with the way the desks are arranged. People are seated with partners and they’re across from each other and the teacher gets to walk around. That’s why I like it; mostly the way the teacher is walking around…Most of the things that happen is that I also have anxiety along with my ADHD. **It makes me really anxious to ask for help in a different classroom environment. It’s easier here.**

Some participants preferred small classrooms because these allowed instructors to be more “in tune” with their students and able to provide students with more individualized attention “especially for people like me who really need your full attention when you’re teaching me something because otherwise, I’m everywhere” (n=4
students). Being able to approach instructors on a one-on-one basis was helpful particularly to those students who have anxiety in asking for help in front of the whole class and do not wish to draw attention to themselves. Students felt that this helped keep them on track with their classes and was a major factor in their “academic success.”

In addition, some participants preferred spaces that provided comfortable proximity or “good learning distance” to the instructors. In fact, with the exception of three, all study participants preferred seating either in front or close to the front of the class. Part of their reasons for choosing to sit in front were to be near the instructors (n=3 students) and be better able to hear and see the instructors and written materials on the board (n=4 students).

And I like the classroom size as well because part of how I cope is by sitting in the front row. I always sit in the front row. And the classroom size is great because that way, I wasn’t too close to the front of the class and not too far either. I felt it is a good learning distance from the professor and the board…Like when I was going to P---- College [name redacted], the classrooms tend to be really small so everything is pushed up and you would feel like you’re too close to the professor sometimes. So what I mean by good learning distance, I wasn’t too close or too far from the professor. It just felt really appropriate in that I wasn’t worried that I’m too far or too close. Just getting rid of that distraction is helpful.

I do [sit in front]. I am the type of person, I would seek out my professors for assistance or clarification or to just communicate with them to enhance the relationships so I can get the most of my education. And I feel like I’m much more focused when I have the seat in front.

Part of the reason why I sit in front of the class is because I know that the professor is watching me. So that’s part of my coping mechanism. I don’t want the professor to see that I’m not paying attention.

**Spaces Conducive to Learning**

Some participants liked spaces that give them the impression that these were places of learning and allowed them to take a mental rest (n=8 students). One student liked a classroom because it felt “open” and “bright” with no major distractions: “I think
the lighting just really made it feel clean and great, and I think it just impacted my perception that I think I’m going to be learning something really great here.”

Participants also preferred spaces that allowed them to “turn [my] brain off a little to give it a rest” to keep them focused in class (n=7 students). Three of these seven participants stated that they tend to fidget or move around as a way of resting their minds as well as to “ground” themselves; two of them would normally sit in the back of classrooms because they did not want to distract other students with their fidgeting as well as give themselves more room to move about. Another three of these seven participants liked the presence of windows that helped their eyes and mind momentarily “looking outside during the lecture sometimes.” Being able to “stare away” helped participants manage the information load they are receiving:

…when I’m learning a new subject and I’m taking in all these new information all at once, it’s a lot to unload so sometimes I just need to kind of stare away from the information on the board and kind of space out a little bit. Yeah, I think focusing a lot on the professor, maybe I would hyper focus and then I wouldn’t be learning anything. So I need that momentary distraction, that momentary change of focus to redirect myself. Sometimes people need to just tune out a little bit, I can just look out the window and see there’s something going on, okay, now I can return to lecture.

Yeah, like during tests sometimes you start getting stressed out so just taking a break and just stare outside and look at the people below, it just kind of calms you down and gets you back.

In addition, three participants stated that they liked having windows in the classrooms because these provided them with the feeling of an “open environment” which, as one participant reported, made students feel comfortable interacting in class.

In terms of environment, if the room feels more open, there’s more interaction between students. For example, I’ve mentioned two of the three environments here, one that I liked and one that I don’t like. One that I have not mentioned would be my English classroom which has windows on the right and left side. It helps to contribute to the openness and allows for more interaction between
**students because they feel more comfortable in the environment and talk more freely.** If environments are more open, students would typically ask more questions. They’ll feel more comfortable and they’ll ask the professor questions pertaining to the subject or just questions to get to know the professor even better.

**Environmental Features with Negative Impact on Study Participants**

Students identified features of classrooms that they felt interfered with their learning. These features included the following: (a) spaces with elements that distract them (n=18 students); (b) density (n=11 students); (c) inadequate work area (n=6 students); and (d) sensory-related difficulties (n=7 students).

**Cognitive Interruptions and Distractions**

All of the study participants reported learning environments that include distracting elements as being less preferred. The following were elements identified as distracting: (a) noise; (b) visual interruptions; (c) outside stimuli; (d) uncomfortable furniture; and (e) cluttered and incongruent spaces.

Participants reported noise as a major distraction, including students talking in class (n=10 students), or “general” types of noise such as outside noise, squeaky chairs, doors that whistle when not closed properly, or high level of noise in large class sizes or large classrooms, all of which affected their ability to hear their instructors and fellow students (n=14 students). It should be noted that some of these students recorded their classes so noise affected the quality of the audio-recording, making it difficult for the students to review their class lessons later.

Lecture halls are probably the most frustrating one. A good example of that one would be C---- Hall [name redacted]. Because things echo, when people drop pencils or when people walk in, or just coughing, it’s extremely overwhelming. You’re trying to listen in on the professor and there’s too much noise.
Another form of distraction were visual interruptions occurring in classrooms such as students walking in late or getting up in the middle of classes, doors opening and closing, too much visual stimuli on walls, etc. (n=7 students). In addition, students reported getting distracted due to the presence of laptops, computers, smart phones, or tablets in the classrooms (n=6 students); e.g., seeing laptop screens lit up across the room and “getting sucked in” as students surf the internet, visit social media sites, or “watch movies.”

Most of the participants stated that in order to minimize these types of distractions, they tended to sit in front or near the front of the room (n=15 students). This allowed them to focus on their instructors and lectures.

I always try to aim for the front because I always will get distracted at one point or another. But if I am, I’d rather be in the front where the distractions are kept to a minimum. If you try to minimize the amount of people around you, like only behind you, you can’t get distracted as easily.

I try always to sit as close to the front of the classroom as possible to avoid any possible distractions like computer screens or lights or what-have-you.

Although spaces with windows were identified by some as contributing to learning, others see these as a distraction (n=5 students), as they tend to “stare” at activities going on outside. Two of the five participants stated that they prefer good internal lighting instead of windows.

Six study participants reported disliking older and uncomfortable chairs in classrooms because these were distracting and painful. For example, the chairs in two of the older buildings on campus commonly were metal chairs and one participant reported that the screws on the back support were digging into her back. Another example was “outdated” chairs that have cracks on the seats and “would pinch [the students’] behinds…and you can’t really see the cracks until people sit down so it pinches them.”
Also, there were many chairs in these classrooms with uneven legs which cause the chairs to rock back and forth, creating a distraction for the students. Lastly, one participant reported that the chairs in one of the large lecture halls on campus were too comfortable such that she tended to slouch and felt sleepy. She also noticed that these chairs gave her a back ache after prolonged seating.

And sometimes also the chair. I know that they can be comfortable but that can be bad because then that puts me where I can slouch all the way down like this [scoots down on the chair. I’ve talked about it with the people in my group and we’re like “oh those seats man, they give me a back ache” and then they come to the stats lab and we ask if we learned anything in the lecture and we’re “no, I was falling asleep in the chair.” And it’s just not me. I know that because everybody else was doing it and I if look around throughout, a hundred something students and we’re all laying really far back like this.

Six study participants reported being distracted in environments that they perceive to be cluttered and unclean. They cited constant presence of chalk dust and cluttered desk arrangements as examples.

It gets a little bit distracting because of all the chalk dust. Like you look in the room, the floor is covered with a lot of chalk dust. And the board, if you put water on it, it’s only going to make the board worse. My teacher comes in and he tries to clean up the board, then after that we can’t even read what he’s writing...the chalk, get it cleaned because that adds feeling to the room. You take that away and it would become a better place to learn because you can focus more on the board. As it is, it’s like there’s a white film on the board and that makes it harder to read what or the legibility of the chalk at times.

Some participants did not like spaces that seemed incongruent with class activities. For example, one student cited a music room that was used for a lecture class; she considered this room not “acceptable for a classroom” and felt “almost like we weren’t prioritized.” The room was distracting because of cluttered chairs and sounds coming from the other music practice rooms in the building.

I think it was some kind of room for the orchestra or practice. But there were no chairs; we had to get those burgundy colored chairs, you know, those old school
ones from middle school. We had to get one and drag it out from where they’re up on the stands and drag it out to make a line and everyone was all over and there were no room to put your stuff.

Participants also cited rooms where desks were re-arranged from rows to different types of seating arrangements (e.g., semi-circular). However, the shape or size of the rooms did not lend well to such arrangements, thus creating a perception of clutter in the rooms.

But I think for this size of that classroom, I don’t know if the placement of the desks fit the size of the classroom. It seemed a little cluttered which made it, for me, a little difficult to focus because I sense the cluttering. Almost as if the space wasn’t being used properly, like everything was kind of shoved to the back a little bit, trying to make a semi-circle. And because it was a speech class we would have to have a good amount of space to present but it could be done another way. I think. It was a lot of clutter… I’d say that a student with an attention disability needs to be able to look at their space a certain way and feel completely comfortable and know that there’s clutter in the classroom, there’s clutter in their mind. So no matter what size of the classroom, it needs to be structured and not desks anywhere and people on top of each other.

There was nothing wrong with the classroom itself but my problem with that particular class is that the professor made us assemble the chairs into a semi-circle and because it wasn’t big enough, there would be just a lot of chairs in the middle. And that was distracting because there are all these chairs here, the classroom looks like a mess, it was hard for people to get out. And I understand why this professor did that, to get rid of hierarchy in rows, which I liked. It just didn’t work in those types of classrooms.

Density and Personal Space

Eleven study participants reported that crowded classrooms as well as those with limited personal “space[s]” were problematic for them. Participants reported not having room to move around, “hard to get in and out of the room” without bumping into somebody’s backpack or stuff on the desks, “restricted,” “clustered,” “confined,” and “claustrophobic.”

I feel clustered. Like today, we were watching a movie in the class and students kept coming in and it’s like they crammed three classes in one classroom. And
students were sitting in front and I get nervous. It’s like someone breathing, too many people, the air is getting heavy. And someone’s eating chips in the class, another was eating tuna sandwich. Luckily, it was not a lecture, just a movie.

Since one of the main challenges of students with ADHD is difficulty in focusing or paying attention, crowded rooms create many opportunities for distractions such as “getting caught up in other things, in other people’s talking, or other people’s voices.” In addition, they felt that it is easy to get “lost in the group” when they are in large classes and thus easy to get disengaged: “I figured out that lecture halls aren’t the best for me. It’s just there’s so many students and easy to just look at your phone and then class is over.” Consequently, they felt that their learning experiences were less optimal in these rooms and preferred to be in spaces that were less crowded.

But the size of the classroom, I would say, depending on the number of people, I think it’s great for more intimate learning because I’m actually taking two different classes in the same classroom, different days. And the number of people in one of them versus another, like 11 in one of them and then 40 in the other one. So the way the information is kind of processed is in a different way just because there aren’t as many students.

There had to be what feels like 40 desks and every desk is full. I have arranged to go to some of the earlier sessions --- my mom was just here to visit --- so I went to the earlier class. Nine o’clock in the morning, everybody still so tired, nobody really wanted to participate, half the students don’t show up. I’m so much more comfortable in that room. There’s nobody in my personal space, people are not ready to chat on things that are not related to the class yet. I had a better learning experience when I attended that class --- and I’ve also just taken my medication, it’s working at that time --- it’s a lot easier for me to focus for the duration of the class.

In addition, some of the study participants carried bulky bags or even multiple bags because they need to bring many class resources with them including books, notebooks, organizers, colored highlighters, recorders, etc. Thus, classrooms with narrow aisles were problematic for them because they were worried people would trip on their “stuff.”
There’s nowhere to put my stuff. I’m always afraid that I might trip someone with my backpack. And I’m like “oh, I’m so sorry.” And I always carry around two books and there’s nowhere to put them. If I put them down here, I’ll forget it. So I’m always worried about things like that.

Heaven forbid that I be thirsty so I try to keep my water and my coffee on the floor under my desk, hoping that people behind me don’t kick it out and then I’ve still got this huge bag of books. So I put that on the floor right in front of me so I kind of sit with legs over it so I’m not tripping other people. But then I got all my highlighters, my white-outs, my pencils, and little zip lock bags on the top pouch so I can reach those if I need to. So I’m constantly, constantly shuffling to be able to access all the resources that I need for that class.

**Inadequate Work Area**

Six participants reported that small desk sizes were problematic for them because they needed to have adequate desk area to put the class materials (e.g., textbook, laptops, notebooks, etc.) to keep track of their class lessons and get organized while in class. They felt strongly about having their “stuff spread out” or within their reach because doing so prevents them from being distracted when hunting for these items and thus allows them to concentrate on their classes and “feel more comfortable to receive the information thrown at [them].”

Every day is a struggle. It’s so hard [emphasis]. I was just working on Italian. That is the class right now that I feel I need the most resources, and the desks are smaller at this campus than they were probably when I was in high school. So I literally have space for just a notebook. But I like to have all of my notes and materials out and stacked up on top of the notebook. Then I have a notebook that I’m going to be writing notes in on top of that. Then I have my Italian textbook on top of that when I need it until I need it and then I can shuffle it down under the notebook. Also, I have my Italian-English dictionary and my planner, they’re small enough to fit on my lap. So I keep all those materials on my lap. It helps me see where I have my resources so that when I need that, and I will know only immediately that I need it when I need it, and by having it out and ready, *it prevents me from getting accidentally distracted on the way to look for it.*

Or the way the desks are, they’re not individual desks. It’s like long desks and I’m sharing a desk with somebody else and I’m kind of just looking at their feet. Like you’re really near my space. Or I’m looking at the left and they’re really near my space. And I’m left to organize everything kind of
straight and I’m trying to figure out what would be the best way for me to focus. It’s so crammed and then I have all my stuff out and everyone has their stuff out and I’m just like thinking, “Where did it go? Where did it go?”

However, one of the eighteen study participants felt that smaller desks actually helped her focus more in class because not having the option of spreading her class materials on the desk help her prioritize what resources to use.

Usually, when it’s smaller one, I actually have to pick one what to have on my desk. So I have to prioritize which I like because I’m thinking “do I need my backpack, my binder and my two folders on here? No, I don’t need that.” So I’ll just have my binder with my paper that I have to do my notes with and nothing else so I get distracted.

**Sensory-Related Difficulties (Acoustics, Lighting, Sightline, and Temperature)**

Generally, participants expressed that when they were in spaces where it was hard to hear the instructors or other students, they felt “lost” in their classes (n=7 students). This was especially true in big classrooms or in spaces where the level of noise was higher. One student also pointed out that audio-recording classes was harder when the acoustics were not good or the level of noise interfered with the recording.

…one of the classes I have right now, which is a big classroom but it’s packed with chairs, so it’s hard to hear sometimes the students when they ask a question. And it’s always good to listen to questions because they may raise things that I haven’t thought about or maybe somebody’s asking something that you already wanted to have an answer to. So that is important because then I’ll have to listen harder to try to take notes or whatever the answer is. And also just makes it harder to audio-recording as well.

Some students disliked classrooms in two of the oldest buildings on campus where classrooms were larger (± 50 seat stations) and many were rectangular-shaped and described by students as “deep” or “long” (n=4 students). They reported that the sightline to the front of the rooms was difficult, especially if one is seated in the back. Also, because these were larger classrooms, the noise level in these classrooms made it
difficult to hear the instructors or students. Similarly, wide rectangular rooms also posed sightline and hearing difficulties from the opposite side of the room (n=2 students).

…what bothers me is that there are these long rows so if you get stuck in the back, the professor and the board are all the way over there. So I can’t see anything. And then if people are rustling their papers or being not focused, then you miss stuff that the teacher says because you can’t hear him over these. So it’s that sort of thing just makes it really difficult for me to focus, to engage, or care about what’s going on.

…it’s so rectangular that I feel like once the professor crosses that halfway line, I don’t pay attention until he comes back to our side. Because he’s writing half of the lecture on one of the boards and I’m writing the notes but then he goes to the other side and not only can I not see, but it’s far and I can’t hear. No connection at all…when he walks to the right side of the room, it projects to the right side. If he goes to the left, you can only hear on the left. And you have the right side of the room saying “What? What?” And he’ll say “Oh, I said this” and then tries to walk back and forth and trying to explain on both sides so I feel like it’s wasting, double his time, restating something twice back and forth.

With regards to lighting, most participants preferred bright and white or fluorescent (n=8 students) or natural lighting (n=2 students) because these “make the rooms more open, more comfortable,” puts them in “study mode,” and generally makes them feel alert. Three participants did not like “old” or “yellow” light because these make one feel “tired” or “sleepy and not interested in things.”

The lighting is like yellowish and it feels like a 1980’s office building and it has a weird feeling in there…it’s not very noticeable but if you’re in there for three hours, you notice everything…it just isn’t a welcoming classroom. There’s no windows, it’s very closed off. I feel like I’m in a basement of an old building…it’s not uncomfortable class, but not welcoming at all.

I think the lighting of the room was also a problem. I would make it one of the fluorescent lights like the ones we have here because I remember the classroom feeling dingy because of the lighting. Even though I knew it was clean, the perception was a lot.

When the lighting isn’t as high quality or a little outdated, it actually makes the classroom feel less clean, although it’s clean, it make it feels less clean, less high quality learning environment. So it’s just extra noise if you will that distracts me
as well because I’m thinking about “is this clean? Not clean?” Appearance has a lot to do with the perception of quality.

With regards to temperature, generally, participants did not like extreme temperatures because they tend to be distracted due to physical discomfort. These discomforts included sleepiness due to warm environments, inability to stay focused due to excessive heat in the rooms, and distracting physical reactions from being too cold.

Very important. Because if I’m too cold, I’m just worrying about the fact that I’m too cold, it’s uncomfortable. And if it’s very cold then I start thinking next time I need to wear this, etc. Also, my fingers can sometimes hurt and then my fingertips also turn blue so I’m worried about my fingertips as well. **What distracts is the physical changes that include temperature.**

I feel like the extreme temperatures can be very distracting because instead of listening to the teacher and paying attention to whatever the professor is saying, I’ll be focusing on how cold my toes are. Or how my teeth are chattering. Or how I’m like so hot and I’ll just start doing this [gestures fanning herself] in the classroom and you know, not take notes, and be distracting to other people. **So I find it not very productive.**

I’d say I’m a big believer that if I’m not comfortable physically, the only thing I’m focusing on is what I’m uncomfortable physically. So if I’m hot and sweaty, all I’m think about is I’m hot and sweaty. So that’s a big factor and especially if you’re going to put forty people in [a] classroom that’s small, then temperature is a very big factor.

**Classrooms with Split Impact on Study Participants**

Although the focus of this study was to analyze environmental features that promote or interfere with learning, as perceived by students, the interviews yielded an unanticipated, yet very interesting, response from the participants. Specifically, the very same classrooms that some students liked, others did not. This split suggests a possible interaction between the student and the learning environment as well as between the learning environment and its use by instructors. There were four specific classrooms that some study participants liked (n=5 students) and others disliked (n=4 students).
One room has a seating capacity of 40 seat stations while the other three rooms are considered to be large lecture halls with seating capacities of 120, 150, and 231 seat stations.

**Room #1 (Seating Capacity 40 Stations)**

The first classroom that yielded a split response among study participants was a 40-seat station room located in one of the newer buildings on campus. The tab arm chairs were arranged front-facing and in rows. It had both a blackboard and retractable projection screen in front. The instructor table was located on the left front side of the room and had a document camera on it.

One study participant liked this room because it provided her with enough personal space to be comfortable: “…so this is my personal space and that’s my classmate’s personal space.” The student noted that the room was spacious because many students dropped the class (Calculus II) thereby making it easier for the remaining students to spread-out in the classroom. Personal space was a big priority for this student because she needs to bring many of her class materials with her; she came in to the interview with a big backpack, medium-sized crossbody bag, and a textbook on hand. She pointed out that she liked having space to put her backpack without encroaching on other students. In addition, this student liked her privacy and the ability to move around in her personal space. During the interview, the student also tended to fold her legs underneath her while sitting which she acknowledged as one of the reasons why she preferred having personal space:

I like to sit weird, I like to put my feet up a lot and I feel if people are too close to me, they wouldn’t be comfortable with me. I would be too distracting to other people.
Another participant disliked this room because he felt that “it doesn’t actually encourage students to interact; just sit, be quiet, and watch.” This was the same student who liked the 78-seating capacity room because it afforded him the opportunity to interact with many people. This student felt very strongly about being able to interact and participate in order to help with his learning.

I think it’s more on the line of the environment. Interaction, like between students, is non-existent. Interaction between student and teacher is minimal. So it’s mostly just us listening to him. Not us trying to interact or solve problems on the board or anything like that…More participation would allow us to study more often or more frequently. And actually practicing the work and trying it for ourselves first hand would be more beneficial if we’re in the classroom with the professor next to us. Because that way, we can get it wrong there and we can learn from it. All we’re seeing is, we’re seeing how the problem’s done but we can’t really learn from a problem that’s completed if we don’t have foundation to the problem.

Conversely, the other student who liked this room did not mind the lecture-style approach of her professor. In fact, she stated that she learns better and prefers that the instructor write out the “derivation, explain the theory, then [he’ll] do some of the homework problems.” However, she was also very interested in the subject matter (i.e., derivations) and would spend a lot of time in the library studying so she could ask questions in class, which she thought helped her pay attention in class. Her learning preference was to have information delivered via lectures only and to keep student-student interactions to a minimum to avoid getting distracted. However, the other student disliked this room because he felt that the smallness of the room did not offer enough distractions to rest his mind a little bit:

Small room allows for easy distractions typically. Same for incredibly large rooms. Like sometimes, if there’s not enough distractions, you can’t stay focused. If there are too many distractions, the same could occur: you could get distracted. So it’s beneficial to have a few distractions just to give your mind a rest, in order to re-focus on the subject.
It should be noted, as mentioned previously, this latter student liked a 78-seating capacity room because of interaction opportunities in the room; it seems that the midpoint between a small (e.g., \( \leq 40 \) seats) and large (e.g., \( \geq 100 \) seats) class size was ideal for his learning style.

**Room #2, 3, 4 (Large Lecture Halls with Seating Capacities 120, 150, and 231)**

There were four study participants who liked features of three specific large lecture halls on campus with seating capacities of 120, 150, and 231, and three participants who disliked these very same rooms. Most of the features of these large lecture halls that students liked or did not like were already discussed: e.g., distractions, instructor mobility, etc. However, one factor not previously mentioned was teaching style, including the way these spaces were utilized by the different instructors. Some of those who felt positively about these classrooms did so because their instructors taught with a mixture of lecture, projection slides, class discussions, videos, etc.: “and then there was a lot of turn to your partner and talk about this (n=2 students). So it was a good mix of lecture or presentation, and kind of individual or partner discussion.” These participants preferred to have opportunities to interact with their classmates and instructors and welcomed a variety of classroom activities to pique their interest.

So apparently, it was one of the biggest classrooms and I think it’s the combination of the professor --- he was very, very good at teaching --- but I think the use of the space was really good because it wasn’t 100% lecture or 100% PowerPoint or 100% group discussion.

Well, it’s more that I like the professor’s teaching style because I’m very, very visual and he has the PowerPoint. And when he was talking about it, he treated the subject more like was putting on a play instead of teaching. So it culled the interest and the subject matter was fascinating which helped.
Conversely, those who disliked these large lecture halls stated that their professors mostly lectured during classes thereby making it hard for them to pay attention, be engaged, or follow the lecture (n=3 students). One participant, who had a class in one of these lecture halls in the evening (7:00 p.m. – 10:00 p.m.) found it hard to be engaged in class or “get involved with everyone” because the class was “socially closed off where [the professor] was talking all the time and it’s very hard to make personal connections with others.” The participant reported that listening to the lecture and “just [sic] looking at PowerPoint for like three hours” was tedious.

I’d rather be involved in discussion more than just looking at a PowerPoint. There needs to be some mixture, you know. And I like group stuff and interacting with people…even if I did all the work for my group projects and stuff, I would still like the interaction of being able to talk to people in the class and have someone to go to if I need help. It’s the hardest for me to get involved in that class and pay attention. I sat like everywhere in the class and no matter what, I just cannot pay attention in the class. There’s no real involvement in the class. He lectures the whole class and all the work is on your own. And when I’m in a class, I like to be able to do the work that’s involved with the class in class so I remember what I did in class to refer back to it. And there’s none of that in the class. It’s just straight lecture for the whole class.

It should be noted that another exacerbating factor for this participant was that this particular class was scheduled in the evening, at which time the effects of the ADD medication that he was taking was waning. One of the side-effects of ADD/ADHD medication is suppression of appetite; thus, this student had not eaten during the day and would get hungry during class, which added to his difficulty in engaging in class.

Me personally, this is not so much about the class but the medicine I take, the ADD, it changes my eating. So like my appetite’s different during the day and it wears off at night and I get really hungry…so my stomach growls at night and I’m like, I just want to go. I’m tired. I’m hungry.
However, the two participants who preferred these large lecture halls did so because of the large class sizes in these rooms, which matched their learning styles. They stated that the largeness of the class sizes allowed them to either “blend in” or have “less pressure” during class. Specifically, one of the students liked the 120-seat lecture hall because “no one notices what you’re doing because it’s a big classroom.”

…and I also liked the fact that even if you blanked out for a while and then you came back in, no one noticed. So you can have time when you can just mentally dose off and turn back on again and you’re perfectly fine.

This student would feel uneasy when too much attention was spotlighted on her and liked that the professor in this room just lectured:

Just lecture. I like that. I don’t like when they ask questions and you have to go forward and start speaking. For me, it’s a little intimidating. For me, it’s more like “don’t call me, don’t pick on me.”

The other participant explained that he felt less pressure on him in the 231-seat lecture hall as opposed to being in smaller classrooms because in the latter, he felt that his questions or comments might be holding up the class and “all attention is drawn on me that I held up the class.” He added that “…in a big lecture hall, it’s opposite; it’s more likely that people will have the same questions, or want to know the same thing, or the professor would take the time to humor the question.” In addition, he stated that in large lecture halls, professors cannot easily gauge whether or not all the students were keeping up with the class materials so they tend to go over the lessons slower than they would have in a smaller class size.

I think the professor can be a lot more intimate with the students in a smaller classroom so he’s able to read how the class feels so if I’m asking a question that he feels that the class already understands, he might not take time to pay too much attention to that question. As opposed to a large lecture hall where a professor has no idea because he or she is not that intimate with every student in the hall most of the time, so they take the time.
This student also observed that student work load in large class sizes (i.e., homework, papers, or projects) was less than those in smaller class sizes; i.e., instructors in large class sizes tend to assign lesser amount of “class load — the expectation for classwork is not the same as the intimate one-on-one class.” He compared two classes that he was taking during the semester of this interview: one in a large lecture hall and another in a small classroom. The instructor in the small classroom “has a lot more work for us to do” versus the instructor in the large lecture hall who just “gives the information” and exams, and did not require papers. Due to his ADHD, this student tends to take longer in finishing projects and essays than his peers; thus, large workloads affect his ability to keep up with deadlines and finish class requirements.

I don’t mind a lot of work sometimes but it takes me a lot longer to complete it than probably most people…Like it takes me usually if I have to complete the assignment and I know it’s going to take me a while, I usually postpone the whole entire day to complete one assignment.

**Traditional and Non-Traditional Classrooms**

Just as some participants were split on their preferences on classrooms, the questions on their opinions about traditional and non-traditional classrooms yielded similar bifurcation. Traditional classrooms were described to participants as forward-facing, row seats with boards or projectors in front, and instructors generally standing in front of the classroom. Non-traditional classrooms were defined as seating arrangements or furniture types that vary from the usual front-facing and row seating arrangements such as U-shaped seating, semi-circular or circular seating, and circular or square tables with students seated around the tables. Participants were asked to identify the effects of these types of classrooms on their attention, class participation, and understanding of
their class subjects. Seven participants liked traditional classrooms while eleven participants disliked these and vice versa.

Seven participants liked the traditional classrooms because they tend to associate a “regular classroom with learning.” They were used to learning in these types of classrooms and it was easy to get into a learning mode. They also liked that the desks were arranged such that all students were facing forward thus making “the conversation between the professor and student very easy” and there was “one thing to look at” or focal point. They also stated that they were able to hear the instructor better, albeit not the other students. They disliked non-traditional classrooms because they felt that these types of classrooms belonged in “pre-school,” the furniture arrangement was distracting and would make them lose focus in class. They felt that these types of rooms did not put them into a learning mode.

But I think the non-traditional one that you’re describing, I feel that that’s distracting if the professor is talking to everyone, and everyone is talking at the same time, like a discussion. **I’ll lose focus just because there’s too much going on.**

...in my experience and just thinking about it, students tend to seem like the rules just don’t matter anymore. It’s non-traditional so it’s a new set of rules. Since nobody has set these rules, they can do whatever they want and that’s distracting.

Yeah, like a [learning] mode. So I feel like if it’s non-traditional, then I think that it’s more easy or more chill and relax. And the more relaxed it is, the worst.

Although four of these seven participants did acknowledge that communication among instructors and students as well as group collaboration would be easier in non-traditional classrooms, they still liked traditional classrooms because they preferred to have lecture classes rather than class discussion; that is, their learning preference was to listen to the information given to them after which they “tend to figure it out” on their
own. They tended to value hearing from the professors instead of other classmates: “I don’t care what my other students say, I care about what my professor says, you know? They’re not the ones giving me the quiz or the test.”

Eleven participants liked non-traditional classrooms because they felt that such rooms promoted “group work” and collaboration. They felt that because it was easier to hear and see their peers, these types of rooms enable easy communication and “allow for an open feeling to be created,” thus making connections with other students easier. It also made it easier to access instructors and allowed “more communication with the professor because he or she is moving around.”

I’m always liking the non-traditional because it’s more personal that you could get with the student: meaning one-on-one or individual. *I think the information gets stored better in the brain, I think for me.*

Specifically, these participants liked either the U-shaped or circular seating arrangements for various reasons such as keeping students in the class more “focused,” encouraging group discussion because it felt “intimate” and helping everybody to be “involved.” In addition, they can hear and see the instructors as well as their other classmates better in these types of seating arrangements.

It’s easier to see or hear most of the time. And then if you have to do group work, it’s a lot easier to sit as a group because you can have kids just pull up chairs on the other side of the U…so they can see each other.

Definitely hear because you’re straight in a circle. She can turn to you, you know, instead of like facing the class and she has to walk over to you. I think if she’s centered in a circle, for me, it just feels like more personal instead of she’s just projecting her information to a series of students she just met last week. You know what I mean? *It gives a personal touch.*

I have had a class in the U-shaped…*I feel like the interaction between the teacher and students is there. And it’s more of a psychological thing where I feel like I’m more of a participant, more of an active learner if you will, especially for somebody who does not raise his hand that much.* So it helps me
because the teacher more easily comes and looks and “How are you guys doing?” “Is everything okay?” Like for group work, “do you guys have any questions?” It’s very simple and it’s very fast, one table to the next.

One participant acknowledged that there was potential for distraction in non-traditional classrooms in the beginning because the seating arrangement was different from a traditional classroom but added that this was something that “once you get used to it, it becomes like out of sight, out of mind. You no longer become aware of it.”

Understandably, these participants disliked traditional classrooms because the seating arrangements made it “harder to talk to each other” and did not promote group work or collaboration. One student reported that traditional classrooms did not promote active learning and tend to separate teachers and students. Another student felt that the structure of traditional classrooms was hierarchical and reinforced the idea of “good students” in front and “bad students” in the back.

Yeah, traditional…I think that the traditional model keeps the sage-on-the-stage and the students separates into different…they’re separate. I don’t normally see teachers come up when it’s that kind of a setting because the spaces just doesn’t allow them to or it’s not set up that way. I don’t really see that in the traditional classrooms. Maybe the teachers have walked up and down, but it doesn’t feel the same, it doesn’t feel like you’re connecting with them. You’re sort of not an active learner. Still, they’re up there and you’re down there.

…again with the traditional classroom setting, it does feel like a hierarchy. There’s always a stigma towards the people in the back of the class. Even in media, they are the ones making noise, who don’t care, the ones that the teachers are always picking on. They tend to be associated, at least in the media, about not caring about their education. So I think it would be good because it would get rid of some of those stigmas. And honestly, I don’t think it’s really going to change anything because the people who are going to be there still not going to want to be there regardless of what the classroom set up is. I just think that the traditional classroom is more of a negative reinforcement of that.
Use of Technology

The study participants were also asked to share their thoughts about the use of technology in classrooms. In the context of this study, technology was defined as computers, laptops, projectors, digital presentation slides, lecture recorders, tablets, clickers, or similar devices. Participants’ responses showed that although most view technology as tools they can use for their learning, they acknowledged that there were problems with using technology in classrooms. Participants used technology to make class content and information more permanent and able to be reviewed by recording and printing out presentation slides of lectures. Also, participants seemed to appreciate the ability to integrate auditory, visual, and kinesthetic modalities and be able to concentrate on one task at a time. However, they did recognize the potential for distraction posed by the presence of technology.

Technology as Tools for Learning

Some of the study participants reported recording their classes on their own using recording devices (n=6 students) or taking advantage of classroom-recorded lectures — recorded copies of lectures in video format that capture materials from the instructor’s computer and audio in the room (n=2 students) so they can review the lectures later. Some re-listen to the recorded lectures to fill in missing parts of their notes while others find it easier to just listen during the lecture and then write their notes later when they can do so at their own pace. These strategies reduced their anxiety about missing class materials during the lecture and helped them to concentrate more on the lectures while in class. While three participants had not heard of existing technology that can record
lectures in classrooms, all three expressed desire to use it because they think this would be useful in reviewing their lectures.

Oh, yeah. Because I don’t…like you said the burden? The cognitive load between writing and listening and comprehending, I feel like other people might be good at that but me, it’s one or the other. I have to either just listen or write notes. I could do a little bit of both, just like little notes. But I don’t get much out of the lecture if I’m trying to write everything down.

Also, it helps with anxiety because I’ll start freaking out that I missed something. So just knowing that I have that recording right there, it’s “okay, I don’t have to worry about that, move on, and I can listen to it later.”

Two participants stated that the use of document cameras or whiteboards that instructors can use to project lesson materials and write on would be helpful so that the instructor can “actually mark up on the white board and it was so helpful, it was integrated…it would really help us see what we were missing, it was really interactive, and cool.” This aligned with the preference of some participants to see instructors work through step-by-step the solution to a problem, particularly in Math.

I’d like to see it worked out but I would prefer the ones where you can write with what looks like an electronic pen and then it shows up so it’s more clear and brighter and easy to see and she can zoom in to show you something. But you’re still seeing her work out the problem. Because if I just see numbers on the screen, I’d be like “no” because I just see numbers right now and I can’t focus. But when it’s “1,2,3, stop, 1,2,3, stop” then I can think and I write down step number 1, step number 2.

Another participant liked the audio quality in a room when the instructor used the microphone because this seemed to help in his learning:

…the teacher can speak into a microphone and for some reason, that amplified volume – it’s not even much louder – it just seems clearer. Or the fact that it’s coming from up here [waves hands diagonally from the ceiling towards his face] instead of this way [waves hands straight from the front towards his face]. I think that’s my favorite part, there’s something about the sound quality, something about it that really made my brain not have to work so hard. I think my comprehension might be better. I’m able to think about more than one thing at a time. Because you know, when you’re listening to a lecture, there’s a lot
going on. You’re listening. You’re reading. You’re trying to figure out what you’re going to write.

Use of Presentation Slides in Class

The majority of study participants are used to having lectures delivered on presentation slides. However, they had suggestions on both the content and use of projected materials. Six participants preferred slides that contain not only written materials but also visually interesting and relevant items such as pictures, graphs, or other reference materials that would explain the concept being taught. In addition, they would like instructors to discuss the contents of the slides instead of reading off the slides “word for word.”

For me, I took a test actually just two weeks ago. I am about 40% visual, 30% kinesthetic, and 20% touch-and-feel like I have to read and write and do it at the same time. So have to do all three for me to learn…I always have gotten more out of a picture than somebody just giving me loads and loads of definition and full of points. I mean it helps, too, but I came to find out that telling a story to me works better. In fact, I get way better grades that way. I’ve had classes like that already and they can’t figure --- my mom would ask me, “Why are you getting such good grades in this class and not in this class?” And I was telling her the way the professor was teaching us is more picture-based.

The visual part of having a projector is really great. I love having a picture to what I’m learning so I could have a mental image and I can save that and make connections mentally.

There are other professors who are like word for word and everything that’s on the PowerPoint and it makes me think like “oh, it’s just word for word, I’ll just read it later” but then I’m never going to read it.

Explaining the picture, yeah! Explaining the picture, not just word for word. Or like a graph, just kind of just explaining it…more interactive as in whatever’s on the PowerPoint, it’s just like a picture and she’ll be talking about what it is.

I like animated. Bullet points are --- I like to process things one at a time. If I see the list, then you start to look at other things on the list and you’re not focusing on what they’re talking about. You’re reading something else.
Related to this, participants shared that, as part of their learning strategy, they used color as visual cues on their notes and textbooks to help them understand and remember important class concepts (n=7 students). For example, some students would assign different colors to written words according to their “urgency” or “associate colors with course.” Or they used color to categorize and associate concepts and ideas. They also stated that it helped when instructors use colors when writing on the whiteboard or presenting materials on presentation slides. This finding aligned with the participants’ preference to have visually stimulating content materials such as pictures or graphs to help in their learning.

When I have my notes the way that I want them, they look similar to this. *They’re color-coded and it really helps me learn.* And then when I go and study for the test, I get the study guide and then I assign a color for each subject.

But as for like color coding for stuff on the board, she’ll use different colors every once in a while but if she had --- like in the next step, the thing that she changed --- if she put that in a different color, that’ll be great.

Two participants differed in the amount of information they prefer on the presentation slides: one preferred to have just “basic information” shown on the presentation slides while the other stated that the amount of content material presented on the slides depends on the complexity of the class material or the level of knowledge on the part of the students. That is, simple concepts can be shown minimally on the slides but new and unfamiliar concepts should be shown with more detail so students do not miss those while writing during lectures.

Depends on the class. I’m taking biomechanics right now and that class is really easy and the whole entire class, I’m just off. The PowerPoints are straight through, he just goes over everything so I kind of have to keep forcing myself to snap back and pay attention for the occasional things I’m not familiar with. So if he went over outlines, I would be perfectly fine. But for that other class, *because*
a lot are new material, I like how he just have everything there so again, if you missed something, you can just look over, it’s right there all set.

Students also preferred having either printed or electronic copies of the presentation slides in advance of the lectures so they can write or type their notes on the copies as they listen to the lectures (n=7 students). One student reported taking photos of the slides, if printed copies are not available. Similar to recording lectures, this allowed them to follow the lectures knowing that they have the materials to review later and reduced the anxiety of missing parts of the lectures.

...there are certain instructors that I’ve arranged accommodations for them to send the PowerPoints in advance. Which is really, really helpful when I print them out and have the hand-out sheet because then I can just add my notes as we’re following along in class.

But I’m still writing notes because what they’re going to put on the presentation isn’t nearly enough information. I need to write extensively. But at least, I know, and I have it, and I can go back to it. Yeah, it wastes paper but if not that, then at least they can post the PowerPoint and we can look at our computers and we can switch back and forth. Yeah, definitely, one or the other, those are useful tools to have.

Also, I really, really, really like professors who print out their presentations. And then I know exactly what I’m looking at, I know exactly how far away we are from the end, I know exactly what they say.

Some participants reported that they preferred to have printed copies of the presentation slides because they need to physically handwrite their notes; doing so reinforced the class content and information (n=10 students).

Also writing and re-writing notes. One thing that really helps to study for a test, literally to go exactly in my notes and start a whole sheet of paper and start re-writing all of them. And I color-code.

Then I go over and write a blue pen over the black pen. I just write over it because it helps me remember whatever it is that I’m learning. And when I’m cramming like ten minutes before the test, I can just flip through all my notes and
anything with color I know is really, really important. But for me I need paper, pencil, textbook, let me write on the textbook.

**Conflicting Perspectives on Technology**

As stated earlier, the participants acknowledged the advantages of using technology but recognized that when not used properly, there were negative effects as well. For example, some support the use of laptops, computers, smartphones, or tablets in classrooms so they can have easy access to information or resources while some find these devices to be a distraction as mentioned earlier. These different perspectives on technology are presented here:

Yeah, depends what it’s for. I had Math 96 over the summer and I was in a class and I had all the computers and stuff on the desk. It was fine for what I was doing because it was an online Math course and it met once a week. So in that case it was really nice and productive. But I don’t know what else it would be good for besides a computer science class or programming or software class. Those classrooms with the computers, as long as we have to use them, then they serve their purpose and they’re fine. I have been in classrooms where there are computers and we’re not using them so it’s not a burden, but it is distracting.

It will definitely be a distraction. For people with ADHD, technology is a gift and an extreme curse. It offers an incredible amount of distraction and it is something that for me, I have to remind myself even, when I’m near technology to always limit myself. If I’m on there, I could be there for hours. It could easily suck you in.

Finally, participants reported having problems with technology in classrooms when (a) the technological devices fail to work in classrooms (n=2 students), (b) instructors do not know how to use certain pieces of technology (n=1 student), and (c) there is not enough access to electrical plugs in the room to charge their laptops, tablets, or smartphones (n=3 students).

I love them but sometimes they fail. Sometimes they don’t work, like the projector. Like today, we had an open book, open note quiz, then the internet
went down and then she had to say that we can ask our surrounding classmates because she had no choice. But if you have an IT person, I would say yeah. But if you don’t, then no.

I think it could either really help or really make it bad because the only problem is when somebody doesn’t know how to use a piece of technology, that usually sets us off like a good 10 minutes every time somebody disrupts because they don’t know how to work their computer or their computer is not working. So that’s the downside of it.

I usually sit right in the middle, right in the front where the board is. And there’s no outlet so when my laptop or something dies, especially if the classrooms are wide, there’s no…at G-- [college name redacted], there was one classroom where every other chair, there was an electrical panel that would flip out. I thought that was pretty interesting.

I would provide a lot more outlets for sure because a lot of the classrooms, you would have outlets in the corner and even if you sit in that side of the room, it would still be really far.
CHAPTER 5. SUMMARY, DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS FOR FUTURE RESEARCH

Introduction

The purpose of this qualitative study conducted at a large, public university was to explore the impact of physical instructional spaces on the learning experiences of students with attention deficit hyperactivity disorder (ADHD) through the conceptual framework of cognitive load theory. The primary data source was one-on-one interviews of eighteen volunteer college students with ADHD. This chapter presents a review of the interview findings, along with discussion of these findings as they relate to the literature review, this study’s conceptual framework, and classroom observations. Implications for planners, faculty and those who support students with ADHD will also be discussed. The chapter ends with recommendations for future research.

Summary of Interview Findings

The eighteen participants were very diverse, not only in basic demographics such as gender, race, or ethnicity but most importantly, in their preferences of the environmental features they perceived to help or hinder their learning. It is important to note that there was not a single specific environmental feature that all students collectively agreed upon, but rather there were many various environmental features identified, some more preferred than others. In addition, there were factors where participants were split in their opinions; that is, there were specific factors that some participants preferred, while others did not.

Some students preferred spaces that allowed them to interact with their instructors and peers. They connected this to small class sizes, small
groups, or seating arrangements where they could work collaboratively with their peers, feel comfortable speaking up, and participate in class discussions. They also felt positively about spaces with furniture arrangements that allowed easy mobility of instructors or where they could sit with good proximity to instructors so they could easily ask questions or get guidance. The majority of these students chose to sit in the front or near the front as a learning strategy so they could see and hear their instructors without difficulty as well as avoid distractions from other students.

Participants preferred spaces that they considered to be conducive to learning. These were open, clean, and bright spaces with no major distractions. These were also spaces where they could momentarily take mental rests. In other words, some students appreciated the presence of windows where they could look outside for a moment, rest their eyes and mind, and re-direct their focus again in their classes.

Conversely, students did not like spaces that have distracting elements such as noise, visual interruptions, outside stimuli, or cluttered and unclean spaces. Students connected these to large classrooms or large class sizes where the presence of many students or windows offer multiple opportunities for distraction, and where spaces seemed incongruent with class activities. They also felt negatively about densely occupied classrooms and tightly spaced seating arrangements. Most of the students disliked small desks, which they considered to be insufficient to accommodate all the course materials and other resources they carry with them.

Additionally, they did not like spaces where they had difficulty seeing or hearing their instructors and fellow classmates. Mostly, they connected these to large classrooms and rectangular rooms that were deep or wide. And they felt negatively
towards spaces that affected them physically such as rooms that are either too hot or too cold as well as those with uncomfortable chairs.

Finally, there were specific spaces that were liked by some but not by others. Upon further analysis, the main reason for these differences was that they experienced different instructional delivery methods employed by the different instructors who taught in these rooms. Those who liked these spaces did so because their instructors delivered class content with a mixture of class activities (e.g., lectures with group work, videos, or class discussions) while others who disliked these spaces did so because their instructors only employed one teaching delivery method, which was usually lecture style. Related to content delivery, the participants were divided on their opinion about traditional and non-traditional classrooms. Specifically, some students liked traditional classrooms because they preferred to have lectures as the main mode of instruction, while others preferred to have a mixture of lecture, class discussion, and group work, which non-traditional classrooms seem able to support more than the traditional classrooms. Further, those who preferred traditional classrooms thought that they had more access to instructors because there was generally one focal point (i.e., the front of the room) and most of them chose to sit in front. They also thought that they could hear or see their instructors better while those who preferred non-traditional classrooms thought they had more access to instructors because these types of rooms allow more mobility and visual proximity for instructors and students.

With regards to technology, students understood that when used properly, technology can be used as a helpful tool for recording lectures and providing visual presentation of course content by instructors. However, they also realized that the
presence of technology in classrooms can be sources of distraction for them such as the use of laptops or smartphones in surfing the internet during class. Thus, these students try to limit their time or avoid using these when studying. Lastly, for the majority of these students, the use of presentation slides in classrooms to deliver lecture content is not a novel idea --- they considered this as part of a classroom, similar to whiteboards and markers. However, they did have preferences regarding presentation slides. They prefer to have advanced print or digital copies of the slides. They also prefer the use of visually stimulating contents on the slides.

Discussion of Findings

Under cognitive load theory, the cognitive resources dedicated to processing new information are limited; however, they are optimally managed when extraneous cognitive load is reduced and germane cognitive load is maximized (Paas et al., 2003). Extraneous cognitive load is the demand created by how the learning material is presented to the learner. This occurs when information or a task is presented with additional elements that interfere with the learner’s understanding. This necessitates the working memory to allocate resources to processing these extraneous elements instead of devoting its resources to the intrinsic task itself. Germane cognitive load occurs when learning material is presented in such a way that eases the learner’s understanding of the material itself, thereby allowing the working memory to re-allocate its resources towards processing the new information and the formation of schemas (Paas et al., 2003; Schunk, 2012). Experts suggest that these cognitive loads are theoretically measurable by analyzing the (a) mental load which is the level of complexity or characteristics of the
task; (b) mental effort which is the amount of resources that the learner exerts in processing the task; and (c) performance of the learner (Choi et al. (2014).

This section will discuss major factors that emerged as reported by students and, where appropriate, include results from the classroom observations to triangulate data collected from the student interviews and findings from the literature review. Those factors are grouped into (a) those with a positive impact on the learning experiences of participants: interaction and participation, proximity and access to instructor, and spaces conducive to learning; and (b) those with a negative impact on the learning experiences of participants: cognitive interruptions or distractions, density and personal and work spaces, and sensory-related difficulties. There is also discussion on the use of technology as tools in the classrooms and by the participants.

Positive Impact on Learning Experience of Participants

Interaction and participation.

The findings showed that the ability of students to interact with their peers and instructors and participate in class discussions increases their level of engagement and motivation in class. According to cognitive learning theory, motivation influences how much attention will be allocated to information received, and how it will be processed (Schunk, 2012). Thus, the higher the learner’s level of engagement or motivation, the more cognitive resources are allocated to processing new information. It could be argued that class discussions, in effect, allow learning materials to be communicated to the learner in different ways: first, from lectures given by instructors and second, from the exchange of ideas during class discussions. This double-pronged approach of presenting information allows the learner to create connections among concepts,
reinforces the learning material, and heightens its relevance and the attention directed to it (Schunk, 2012). Spaces that allow student interactions and participation, therefore, promote germane cognitive load.

But I do appreciate when other students have valuable contributions to the class conversation and it makes it more memorable when it’s put in somebody else’s words other than the instructor or my own. And I retained a lot of material from that class. It wasn’t being taught the same thing the book was teaching me. **It was elaborating on that and the more that you discuss it in different ways, the more effectively I could grasp the material.**

The environmental features identified by participants that support student interactions are small classrooms or small class sizes as well as seating arrangements that promote collaboration and group work such as those found in non-traditional classrooms. There were no non-traditional classrooms observed but these findings on classroom size align with the direct classroom pre-interview observations conducted in Fall 2015 on three college algebra classes of varying class sizes: 38-seat, 60-seat, and 121-seat station classrooms. Each class was observed once within two weeks of each other, from beginning to end of each respective class meeting. Each of these classes was fully enrolled and the rooms were filled to capacity on the days these were observed. The observations showed that the level of student participation in the 38-seat station room was significantly higher than those in the 60- or 121-seat station classes; in fact, there was no significant variance in the level of student participation between the 60- and 121-seat classrooms.

The students in the 38-seat classroom seemed more at ease with each other and the instructor; there was an atmosphere of familiarity among students during class. In working through math problems, students would ask clarifying questions such as “wait, I don’t get why you did that,” challenge some answers such as “I did it this way” or ask
“can you please go over that again?” Some students would raise their hands when they had questions or comments but mostly students would just answer or ask questions or the class would group-speak. Since the classroom was small, voices were audible and were immediately responded to by the instructor. In fact, when one student seemed confused, the instructor was able to pick up on the confusion right away and re-work the problem with the class, which clarified the solution for the student. In summary, roughly about 85% of students in the class were interacting and participating in one way or another, and about half of the class was actively interacting and participating.

The post-interview observation findings of a pre-calculus class in the same 38-seat station classroom showed that the level of student participation, although not as high as with the pre-interview observation in the same classroom, was still significantly higher than those of the 60- and 121-seat station classes observed during pre-interview. This post-interview observation was conducted a semester later with a different instructor. As mentioned, the level of student participation in this class was not as high as those observed in the pre-interview class, but still considerably high.

The difference, in terms of classroom dynamics, was the degree of familiarity among students and the ease with which students interacted with each other and the instructor. There were various factors that could have affected this. First, the length of time into the semester when classes were observed; i.e., the pre-interview class was observed almost at the end of the semester (on the 12th week of the semester) while the post-interview class was observed almost at the beginning of the semester (on the 7th week of the semester), thus the first class had more time spent with each other and were more familiar with one another. Second, the time of day these classes were scheduled:
the first class meeting time was in the morning (start time was 11:00 a.m.) while the second class was towards the end of the day (start time was 2:00 p.m.), when students might be more tired and ready to conclude their class day. Third, because the first class was observed during the latter part of the semester, students were probably already gearing up for final exams and more motivated to grasp the class materials while the second class just finished their mid-term examination for the class that week, thus the students might be taking a mental rest during the day it was observed. Nonetheless, all these factors considered, this class still had a significantly higher level of participation than the two other large classes observed.

With regards to the two other large classes observed, due to the size (large) or shape (deep or wide) of the rooms, there were difficulties in hearing the instructors and students clearly. Also, the sightline to the front of the room was problematic in the room that was deeper than it was wide. Based on these observations, these factors probably contributed to the low participation rate witnessed during the classroom observations.

**Instructor mobility, proximity, and accessibility.**

The findings showed that instructor mobility and student choice seating (i.e., front seating) help increase interactions between instructors and students and make it easier for students to ask questions and get guidance. The ability to ask questions or clarify concepts help reinforce the learning material which promotes germane cognitive load on students. In addition, the perceived ease with which students can connect with their instructors and get guidance reduces students’ anxiety, and thus could be considered to be a factor in reducing extraneous (i.e., anxiety) cognitive load.
Earlier studies by Sommer (1967) and Becker, Sommer, Bee, and Oxley (1973) showed that clear visual contact and access to the instructor affect student participation, particularly where instructors had more mobility and interaction with students. In addition, some classroom interventions recommended for school-age children with ADHD include arranging the classroom in traditional row-seating pattern (this is considered to be very structured and predictable for the students) and placing students with ADHD in front and near the teacher’s desk so they would be less distracted and thereby allowing the teacher to provide immediate feedback to the student (Carbone, 2011; Reiber and McLaughlin, 2004). Their studies and recommendations align with the findings of this study where the majority of participants felt that small classrooms, small class size, furniture arrangements that allow instructor mobility, and ability to sit close to the instructors were factors contributing to their participation in class.

Further, both the pre-interview and post-interview classroom observations of math classes previously mentioned showed that generally those who were participating in class discussions were those seated up front and close to the instructors. This was observed in the 38-seat classroom conducted during the pre-interview observations. This instructor used a document camera, to work through math problems. The document camera was placed on the instructor’s table, which was located in the left front side of the room. Since the instructor could not move from the document camera, the degree of student participation fanned out in an arc, with those seated closest to the instructor participating more than those on the farthest wall and back corner who were participating less.
This fanned out arc was not observed in the post-interview observation of the same classroom where the instructor wrote and utilized the whole length of the whiteboard. Instead, it was observed that students sitting in front seats the full width of the room participated more than those in the back and corners of the room. This same phenomenon was observed in a religious studies class where the instructor walked back and forth across the width of the front of the class: those seated in the first three to four rows were more responsive to the instructor’s questions and comments than those seated in the back. However, again, there may be other factors at play that contributed to the lack of responses from the back of the room for this particular class such as blocked sightline or inability to hear the instructor; this may be an area for further research.

With regards to instructor mobility, all four-math instructors were able to walk up and down the aisles during periods when students were working on math problems on their own. However, because of the large class size in the 60-seat and 121-seat classes and chairs closely arranged in front of one another with no space to walk in between, instructors could not cut across the room directly to students needing help; rather, they either would need to walk up front or to the back and then to the aisle where students were seated, which resulted in a loss of instructional time and was inefficient. As it was, the instructor in the 60-seat class reported that the large size of the room prohibited him from getting to all of the students within the duration of the class session. The reverse was true for the 38-seat classroom; because the classroom was small, both instructors were able to stop at most of the students’ desks.

These observational findings, along with the interview results, point to connections between classroom size, class size, furniture arrangement, instructor
mobility and proximity, and students’ participation and engagement. A limitation of this study is that there were no non-traditional classrooms observed; therefore, no comparisons were made with regards to student participation and engagement in these environments. This may be an area that warrants future research.

**Spaces conducive to learning.**

For study participants, spaces that are open, clean, and bright create a perception that these are places of learning and help students to mentally ready themselves to learn which promotes germane cognitive load. Conversely, as reported by students, cluttered and unclean spaces as well as spaces that seemed incongruent with the type of activities happening in those spaces increase extraneous load because these extra elements in the space detract learners from fully investing their attention towards learning.

The meta-analysis of Weinstein (1979) and Temple (2008) on the impact of instructional spaces on student behavior, attitudes, and achievement showed that the physical environment has an impact on the attitudes of students towards learning. Specifically, satisfactory rooms were “associated with better attendance, greater participation, and more positive attitudes toward the class, the instructor, and classmates” (Weinstein, 1979, p. 598). Temple (2008) concluded that space designs should consider the “social underpinnings of learning” and create “welcoming and flexible spaces” (p. 238) that would promote learning.

This was observed in classroom observations conducted in two introductory geography classes in Fall 2015. These were two class sections of the same course, taught by different instructors and in different rooms. The first section observed was in
a 125-seat classroom located in one of the newer buildings on campus. It has stadium-style seating, good lighting, warm creamy yellow wall painting, and high ceilings that create an open and spacious atmosphere. The room has minimal décor with clean lines. Overall, this room provides a comfortable, clean, and ambient atmosphere.

The second section observed was in a 42-seat classroom, located in one of the older buildings on campus. The room has old-looking fluorescent lighting boxes, and old-looking, mismatched ceiling tiles. The room is square and painted white; the left and front walls are brick painted over with white paint. The back wall has a blackboard on the right and a cork bulletin board on the left, both which seemed to have been unused for quite some time. Although the whole length of the left wall has windows, these are head high with drapes and blinds, both of which looked worn. The front wall has two mismatched boards, one black and one green, with eight rolled-up maps fixed to the top of the blackboard and one big globe hanging in front between the two boards. Overall, the general feeling of this room is tired, cluttered, and dingy --- not necessarily dirty, but just has the perception of dinginess.

The level of student participation and attention given by students to the lecture was perceptibly higher in the first class than the second. Students were more responsive to the instructor and asked more questions. Of course, there may be other factors that might be at play during these observations such as time of day (first class was observed at 9:30 a.m. while the second class was observed at 2:00 p.m. when students may be more tired); and the sightline to the front because of the difference in flooring (first class has tiered flooring while the second class has flat flooring which made it harder to see the faculty seated in front of the class) and size of the projection screen (larger in the
first class, smaller in the second class). Further study might be warranted that controls for these other factors.

**Mental Rest.**

Students reported that when there is information overload, they need to give their minds a momentary rest so that they can redirect their focus back to the lessons at hand. This relates to the concept of attention restoration theory, which posits that voluntary attention requires effort and causes attention fatigue; however, allowing individuals to use involuntary or effortless attention will restore attention capacity (Berto, 2005; Staats et al., 2002; Tennessen & Cimprich, 1995; Herzog et al., 1997). Giving students opportunities to mentally rest their minds so they can re-focus their attention to the task at hand lessens the mental effort needed for processing information because the cognitive load is reduced. This allocates more working memory resources towards processing information that is intrinsic to the lesson materials. The students identified the presence of windows as a feature in classrooms that helped them take these mental rests. In addition, the ability to record classes reduces the students’ cognitive load because it reduces the anxiety associated with missing important class content when they take momentary mental rests.

**Negative Impact on Learning Experience of Participants**

**Cognitive interruptions and distractions.**

As reported by students, noise, visual interruptions, blocked sightline, outside stimuli, and other sources of distractions negatively affect students’ cognition by preventing the brain to fully focus its attention towards learning. These unnecessary stimuli increase extraneous cognitive load for the students. As one student stated: “my
attention span can vary. It is less likely for me to maintain my focus when I am exerting additional effort to drown out distractions.”

Studies on effects of noise, lighting, and temperature found negative correlations to cognitive performance of learners (Knez and Hygge, 2002; Hygge and Knez, 2001; Knez and Kers, 2000). For example, increased background noise decreases long-term memory recall on subjects; researchers believed this was caused by irrelevant stimuli during the acquisition of information to the brain (encoding phase of cognition) or “divided attention effect” (Knez & Hygge, 2002, p. 716). In essence, the brain’s cognitive resources are not fully allocated to the acquisition of information because it is also processing irrelevant or extraneous information (e.g., noise) at the same time. Thus, the ability to recall important information decreases.

Almost all spaces offer some form of distraction as reported by the students. This was confirmed during observations conducted in ten classrooms in Fall 2015 (n=9 rooms) and Spring 2016 (n=1 room), four of which were large lecture halls (231-seat, 155-seat, 125-seat, and 121-seat), two large classrooms with 75-seat and 60-seat stations, and three regular-size classrooms with 49-seat, 42-seat, and 38-seat stations. Those classrooms with tiered flooring proved to have the most visual interruptions when one is seated in the back. This is due to the presence of lit-up monitor screens of laptops, tablets, and smartphones that are visible down across the room. In classrooms with flat flooring, mostly laptop monitors can be seen, and occasionally smartphones or tablets when students prop these up on the seats in front of them or are used by students in the immediate vicinity. All of these visual interruptions were particularly distracting when
students were browsing the internet or watching movies since the constant movement on
the lit-up screens easily catches one’s attention.

Also noted to be potentially distracting to students were the combined opening
and closing of doors; the accompanying outside noise filtering into the classrooms when
doors were opened; the actual “whoosh” sound from opening doors; the sometimes loud
and sometimes soft “bang” of closing doors; and late students walking in the middle of
classes; these were seen and heard during all classes that were observed.

Three of these large lecture halls (155-seat, 125-seat, and 121-seat) however,
have rear entrances, thus interruptions occurred mostly from students walking towards
their seats and not the actual opening and closing of doors. This is opposed to another
two observed classrooms (75-seat and 49-seat) with entrances located either on the front
(75-seat room) or side-front wall (49-seat room) which immediately interrupted classes
once doors were opened. The 42-seat classroom has its door located in the middle of the
back wall but this leads immediately to the center aisle and the only way students can get
to their seats would be to walk upfront and either turn left or right and back down the
side aisles, thus immediately providing interruption to the class.

Outside noise did not pose potential distraction to the 155-seat large lecture hall
because it has antechambers on both backside doors that filtered outside noise; however,
potential distraction was from students walking along the aisles and to empty seats,
which seemed to be mostly located in the middle rows. Similarly, the 231-seat large
lecture hall has antechambers for the entrances located on each side of the room, about
one-third distance from the front. Those seated on the front one-third of the room would
not necessarily be disrupted by late-comers, unless the latter choose to sit in the front one-third rows. Theoretically, since most of the students in this study preferred to sit in front, these interruptions may not distract them. However, the doors of this classroom have automatic opener for ADA compliance and emit slight “whoosh” sounds when opened. This did not prove to be distracting to this observer; however, one of the study participants who had a class in this room specifically pointed out that this bothered him. Which leads to the question of what degree of distraction is acceptable for non-ADHD students but would be hindrance to students with ADHD?

**Density and personal space and work spaces.**

Inadequate personal and work spaces increase the extraneous cognitive load because learners are pre-occupied with their own discomfort and sense of disorganization, thus preventing them from fully engaging in their learning. Students preferred to have comfortable personal space between them and other students as well as adequate work surface area; these reduce discomfort, anxiety, and distractions, which then allows students to direct their focus on learning. When students’ attitudes towards their learning environments are positive, their motivation for learning increases thus allocating more working memory resources into acquisition and formation of schemas or knowledge (Weinstein, 1979; Temple, 2008; Schunk, 2012). This was observed in the 60-seat station room math class as well as in the 231-seat station sociology class. Due to the large size of the room and density of the math class, sound seemed to have been absorbed such that it was difficult to hear the instructor and the students. In the 231-seat station room, the collective body heat made the room feel a bit too warm. Thus, the effect of large class sizes, closely arranged furniture, and small desk sizes should be
taken into consideration for space and schedule of classes planning. As one student stated:

*I feel that I had to study a lot harder.* I understood the professor it’s just sometimes, it was kind of annoying…I think it’s too large. It’s just way too crowded. *I could be worrying about the material instead of worrying all other things around me.*

**Sensory-related difficulties.**

Those features of classroom that either hinder registration of stimuli through the senses (e.g., difficulty hearing due to poor acoustics of the room or blocked sightline due to room shape or furniture arrangement) or negatively affect the participants physically (e.g., poor lighting, too hot or too cold rooms) are problematic because (a) information is not fully received or (b) the learner is exerting too much mental effort getting to the information due to unnecessary or irrelevant stimuli.

Past studies found that elements of spaces such as lighting, noise, and heat have effects on cognitive performance and emotional state of subjects (Knez & Kers, 2000; Knez, 1995; Hygge & Knez, 2001; Knez & Hygge, 2002). In addition, Evans (1979) showed that individuals’ stress levels in response to their environment affected their ability to perform tasks. The findings from this current study indicated that when students are not physically comfortable or have sensory-related difficulties, their attention focuses on their discomfort rather than the class material. As one participant student stated: “a student with an attention disability needs to be able to feel comfortable physically and mentally.”

Because I feel like a physiological change, like a physical sort of my brain is now focused on how uncomfortable I am and how I wish that I was sitting over there, or I wish this or I wish that. But it totally takes me away from the moment or what I’m supposed to be doing.
Use of Technology as Tools

For these students, the use of technology, such as microphones, a document camera, or projection slides seemed to be as much part of classrooms as a whiteboard and markers. Providing students advanced printed or digital copies of presentation slides and the ability to record lectures help them with their note-taking as well as reducing the anxiety of missing important concepts from lectures. Students shared that the combined tasks of listening, understanding, and note-taking can be too much of a mental load, thus it helps if there are tools they can utilize to help ease this load. For these students, having a permanent record of class content either via recorded lectures, note-taking, or printed or digital copies of the presentation slides seemed to ease this load because they can concentrate on listening and understanding, instead of trying to do multiple tasks at the same time. When used properly, technology can promote germane cognitive load and/or reduce extraneous cognitive load.

With regards to the use of presentation slides in delivering class content, students generally preferred to have less text and more visually stimulating elements on the slides such as pictures or graphs, with the instructors explaining topic concepts to help them connect learning materials together. In cognitive learning theory, these relate to two concepts: “modality effect” (Paas, Renkle, and Sweller, 2004, p. 6) and “redundancy effect” ((Liu, Lin, Gao, Yeh, & Kalyuga, 2015, p. 304).

There is ongoing debate on the effectiveness of the use of projection slides in teaching delivery; however, this is not the focus of this research. See Hill, Arford, Lubitow, and Smollin (2012) and Szabo and Hastings (2000) for further discussions on this topic.
Course designers apply modality effect when there is cognitive overload in one sensory modality (e.g., visual due to too much text) by transferring the cognitive load to another under-loaded sensory modality (e.g., auditory) to balance the total cognitive load (Paas et al., 2004). In this context, using pictures as visual representation (instead of text) combined with audio narration (i.e., instructor explaining the picture) increases processing of the germane concepts of the topic because the learner is able to use both visual and auditory senses to connect the information together without creating cognitive overload.

The key here though, is balancing cognitive load: replacing too much text with picture and audio narration transfers the load from visual to auditory and vice versa. However, when a presentation slide has all three components --- text and pictures and audio narration (e.g., instructor reading text on the slide) --- there is possibility of “redundancy effect” which occurs when information is presented using multiple modalities that just basically “re-describe each other” and “may unnecessarily waste limited working memory resources on processing redundant information and thus impede learning” (Liu, Lin, Gao, Yeh, & Kalyuga, 2015, p. 304).

The modality effect was observed in two classes in Fall 2015, a sociology and a geography class, both held in large lecture halls (231-seat and 125-seat rooms, respectively). Both lectures were presented using presentation slides, which had a variety of content materials such as text, pictures, graphs, and videos. On occasions when relevant pictures and videos were presented with the instructors providing context behind these visual representations, there were perceptible shifts of attention such as students sitting up straighter, leaning forward on their seats, or putting down cell phones.
And there were responses from the students such as asking questions, stating comments, or affirming responses from questions posed by the instructors related to the material presented such as nodding of heads or general murmurs of “uh huh,” “yeah,” etc.

The redundancy effect was observed in a class in Fall 2015 where presentation slides contained graphs, and next to these were many lines of text explaining the graphs, with the instructor reading the text from the slides. There were visible signs of disengagement from the class such as students on cell phones, laptops opened on internet browsers, slumping on chairs, leg shaking and fidgeting, and few to no responses on questions posed by the instructor.

Lastly, students preferred when learning materials were given incrementally or step-by-step. This method of teaching delivery was utilized by all math instructors in the four classes observed. But of particular interest were two of these math classes observed in the same classroom (38-seat station room) but with different instructors. As mentioned earlier, the first class had more class participation than the second class. Both instructors were very knowledgeable of class content and both had engaging teaching styles. However, two differences were observed between the two classes pertinent to environment: (a) the use of a document camera in the first class while the second class used whiteboards and markers to work on math problems and (b) the use of a workbook in the first class while the second class used a textbook.

The instructor in the first class used the same workbook that the students were working on, projected the workbook on the document camera, and proceeded to work with the students on the workbook problems. Thus, the students were able to see the
problem and the solution together in one visual; they could mimic the solution exactly on their workbooks. The responses from students in this class (e.g., clarifying questions, comments, or answers to questions) were quick, resulting in back and forth discussions between instructor and students.

In comparison, the instructor in the second class referenced the page and number of the problem they were working on, wrote the formulaic representation of the word problem on the board, then proceeded to work on the problem with the students. The students then had to connect the textbook problem on their notebooks and write down the solution. The responses were slower in this class and sometimes necessitated prompting from the instructor. One can posit that “split-attention effect” occurred among the students in the second class, which occurs when a learner’s attention cannot fully focus because there are two or more separate sources of information using similar sensory modality (e.g., visual) (Mayer and Moreno, 1998). In this case, the students’ attention shifted back and forth between the textbook, whiteboard, and their notebooks. There may be other factors that need to be considered in explaining these differences, which this study did not cover; therefore, this is an area that may have implications for further research.

**Implications of Findings**

**Implications for Students with ADHD**

The research question looks into how the different architectural characteristics and design elements of the physical environment impact learning experiences as perceived by college students with ADHD. Implicit to this question is whether there is a learning environment model that would work uniquely for college students with ADHD.
Addressing this question must take into consideration the unique characteristics of students with ADHD.

The responses from the study participants showed that the impact of the physical environment on their learning experiences aligned with findings from the research literature, even though these studies were conducted with the general student population. In addition, their responses aligned with findings from direct classroom observations which included both students with ADHD and general student population. Upon further analysis, however, findings from this study suggest that the negative effects of the physical environment tend to be magnified in students with ADHD. In other words, negative effects of the physical environment may be exacerbated by the symptoms related to ADHD (i.e., inattention, disorganization, and other deficits in the executive function of the brain). So while students without ADHD may have the ability to ignore or easily overcome those negative effects, students with ADHD either cannot or the impact on them is magnified.

One such effect, as reported by all study participants, is their tendency to get distracted and stay distracted for longer periods of time than most students. This is problematic because attention is most needed during the input stage of information to the learner when the working memory tries to filter in what it perceives to be important and filter out what is not; thus, the learner’s ability to pay attention to what one perceives to be important helps in absorbing data and processing information (Schunk, 2012). Thus, in designing and renovating classrooms, planners need to be cognizant that architectural and design elements (e.g., acoustics, lighting, sightlines, temperature, etc.) that may seem to be a passing distraction for the general student population may have a lasting
negative impact on students with ADHD. For example, the amount of echoing in a classroom that might be tolerable for non-ADHD students may be too distracting for students with ADHD. Or the fact that many students record their classes, thus poor acoustics in classrooms would affect the audio quality of their recorded material.

The appearance of classrooms also differentially affects students with ADHD; spaces that they perceive to be places of learning increase their motivation for learning because motivation influences how much attention will be directed to the information received and how information will be processed (Schunk, 2012). Conversely, cluttered rooms and spaces that seem incongruent to the course curriculum are distracting and increase the learner’s extraneous cognitive load. Thus, maintaining these classrooms clean and clutter-free throughout the day has implications with regards to allocation of resources on facilities maintenance for campus administrators. So too, is updating classroom furniture and fixtures to make these spaces comfortable and welcoming.

And I wouldn’t say it’s the design of the room. I would say it’s how engaged you are, how you kind of how to train yourself in trying to filter things out but I think just very, very low quality rooms or material --- they’re not distracting but they’re less preferred. Uncomfortable. It’s not anything you can’t get over but it doesn’t make it easier.

It would be nice to have a classroom that you’re meant to come in, you’re meant to learn, not like it’s been converted from this to this quickly.

Personal space is probably an issue for most students; however, for students with ADHD, this is especially an issue because lack of adequate personal space not only affects the comfort of these students but most importantly, their ability to focus on their course content. In addition, being in comfortable proximity to instructors and the ability of instructors to move within classrooms are important to them. These have implications
for planners and administrators when making decisions about the types of furniture to equip classrooms with and the number of seat stations to assign in classrooms. Specifically, planners need to take into consideration that densely arranged tables and chairs do not allow sufficient personal space and limit instructor mobility, both identified in this study as having an impact on students.

I would say try to make every classroom a learning friendly atmosphere where you know, the desks are not always just like right next to each other. I know you have to have that when it’s a large class but there is a way that you could give a little bit more space and some legroom and maybe some larger desks.

**Implications for the General Student Population**

Nonetheless, although there is not a unique learning environment model that is optimal for all students with ADHD, these features of the environment noted in the research for the general population and magnified for students with ADHD could be immediately acted upon by campus planners and faculty because their negative effects generalize across student populations. One such feature is the size of desks or work surface area in classrooms. In making decisions regarding classroom furniture, campus planners can take into account that students these days carry laptops or tablets in addition to their textbooks and notebooks, so larger desk sizes will help students work with these different resources simultaneously on their desks. The added challenge for students with ADHD is their need to carry with them many other class resources such as recording devices, organizers, different colored highlighters, markers, etc. that they use as learning strategy tools.

Relatedly, another feature to consider in designing classrooms is adding electrical outlets at strategic access points throughout the room to accommodate the
increasing use of personal technology devices in classrooms. Students with ADHD, although they realize that technological devices can be distracting for them, do recognize that these are potentially useful tools. But they tend to sit in front-center of rooms where electrical outlets would not normally be found.

Another feature to consider in designing for larger classrooms and/or rectangular-shaped rooms are sightlines and acoustics from all seating angles. For example, installation and use of voice amplification devices for classrooms with over 60 seat stations would help in carrying sound that would otherwise be absorbed due to the density in the classrooms. Installation of dual projection screens for wider rooms or larger and higher projection screens for deeper rooms would help students seated in the back or sides of the room see written materials in the front.

In addition, walkable pathways between rows and aisles would allow instructors to easily move around the room, enabling proximity to students seated in the back. Good quality lighting, sound, and ambient temperature would help students be comfortable in classrooms. And finally, open, clean, and uncluttered spaces create a welcoming environment. In addition, when we are making decisions on allocation of resources, administrators are advised to be aware of the importance of maintaining the appearance and conditions of classrooms so these spaces are perceived to be places of learning.

Implications for Diversity in Learning Styles

Finally, there were spaces that were liked by some students with ADHD but not by others. Upon further analysis, the reasons for this dichotomy mirrored study participants’ preferences for traditional classrooms versus non-traditional classrooms.
That is, participants tended to prefer spaces where the instructors’ teaching style fit the respective participants’ learning style. In Room #1, two participants had the same room, same teaching delivery style, but different student learning styles. The participant who disliked this room did so because the instructor mostly lectured, which did not fit his learning style preference of interaction and discussion of class materials. In contrast, the participant who liked this room did so specifically because the instructor mostly lectured, which fit her learning style preference of listening and digesting materials on her own. The latter participant’s learning style seemed to align with those who preferred traditional classrooms, where instructors lecturing in front of classes tend to be the focal point thereby affording less distractions and more opportunity to listen to the lectures. Students with this learning style learn best when they can receive and absorb information in a structured manner. With lectures delivered to them, they digest the material on their own: “I tend to figure it out, when I don’t understand something. I find that if I struggle for hours on end, I learn it or memorize it better than asking it right away.” For these students, being in a traditional classroom — front row seating, furniture facing forward so students have one focal point, instructor and writing or visual medium (e.g., whiteboard or projection screen) in front — fit their learning style because they can be in their space of listening, understanding, and learning.

On the other hand, in the other three rooms that elicited split responses from the study participants, they had the same rooms, same student learning styles, but different teaching delivery methods. Those who liked these rooms did so because their instructors delivered class content with a mixture of class activities (e.g., lectures with group work, videos, or class discussions) while others who disliked these spaces did so because their
instructors only employed one teaching delivery method, which was usually lecture style. One can thus conclude that these two sets of participants have similar learning styles, which aligned with those who preferred non-traditional classrooms where teaching delivery styles tend to have mixtures of lectures, class discussions, and group work. These students learn best when they can ask questions, interact with others, or discuss the lesson materials. Thus, being in spaces that allow class discussions, group work, and inter-student collaborations fit their learning styles. These spaces could be non-traditional classrooms such as seminar-type rooms where the furniture is arranged in U-shaped or circular pattern, or active learning-type rooms where furniture is flexible and can facilitate group work.

A close look at the individual study participants’ preferences related to room size, teaching style, and choices between traditional and non-traditional classroom configurations showed close relationships among these factors (Table 4). The majority of those students who preferred interaction and participation, and to a certain extent instructor proximity and mobility, also preferred a more interactive content delivery, non-traditional classrooms, and small classroom size. Those who tended to prefer traditional classrooms also tended to prefer larger classroom sizes and lecture-style of teaching delivery. There were a few students who were outliers to these clusterings, but this general pattern reflects their different learning styles.

Other correlations such as age, onset of symptoms, timing of diagnosis, or gender were analyzed to see whether there were underlying factors that would explain this clustering of preferences but none surfaced from the data. Future studies may want to
look at what contributing factors in the social, educational, or other related background characteristics shape a learner’s approach and style of learning.

Table 4. Student Preferences and Learning Style, Instructor Teaching Style, and Environment

<table>
<thead>
<tr>
<th>Participant</th>
<th>Interaction and Participation</th>
<th>Interaction and Accessibility</th>
<th>Proximity</th>
<th>Lecture Style</th>
<th>Traditional vs Non-Traditional</th>
<th>Classroom Size¹</th>
<th>Comments</th>
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<td>✓</td>
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<td>✓</td>
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<td>Likes one focal point</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
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<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>Depression</td>
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¹ Small Size Room: <40 seat stations; Medium Size Room: <100 seat stations; Large Size Room: >100 seat stations

Thus, ultimately what these findings showed is that there is no one-size-fits-all solution that would serve the learning styles of all students with ADHD. There are interactions between the students’ learning styles, instructors’ teaching delivery methods, and the structure of spaces. This diversity in learning styles and their
interactions with teaching and space present challenges to and have implications for planners, faculty, advisors, and students. The principles of universal design for learning --- looking into the “what”, “how”, and “why” of learning --- seem to be relevant to this discussion, as these principles, currently used to inform curriculum development could apply to space design as well (National Center on Universal Design for Learning, 2014; Center for Applied Special Technology, 2015). This is an area of study worthy of further investigation.

…when I’m interacting with the material in a tactical way of my own learning style, that’s when I learn best.

But in regards to the classrooms…give people the option of whatever’s conducive that allows them to learn better if they know their learning style.

For planners, the implication is to design spaces that are flexible and that allow diverse teaching modes, including the ability to have students work in small or large groups, increase interaction among students and instructors as needed, and easily change the environment to fit instructors’ pedagogical needs (Painter et al, 2013, Sparrow and Whitmer, 2014).

For college and department administrators, the implication is to provide faculty training on effective ways of teaching in different types of spaces and engaging students with different learning styles. For example, large lecture halls may require a different type of teaching delivery to engage those students whose learning styles are geared towards active participation and interaction with other students. Or administrators may provide training on how to use technology to visually and acoustically engage students by delivering class content through various media. In addition, similar to faculty evaluations given on a semester basis, administrators might consider giving students the
opportunity to provide their input through space evaluations to keep a pulse on the emerging needs of students related to the physical environment.

I don’t know if there are more that can be implemented, I don’t know specifically what else could be but I feel that **more input from students like me** would be better. Which is what you’re doing right now. And that’s why I was so quick to jump on it because I knew that this is something that needs to be addressed.

For faculty, understanding not only that space dictates the kind of teaching delivery they can do but also that students’ learning styles intersect with the way they use space in teaching. A teaching delivery method that may work for students who thrive in an active learning space and prefer to have interactions with other students, work in small groups, or engage in active class discussion may not work for students whose learning styles are most suited for listening to lectures and understanding class materials on their own and vice versa. A teaching delivery method may work best in non-traditional settings but not in traditional ones. Faculty need to understand, too, that some students in their classrooms may have ADHD and that they need to capture these students’ attention and keep them engaged by delivering class content using different teaching modalities and visually stimulating lecture materials. In addition, similar to online course design, instructors can apply the concepts of cognitive load theory to content materials projected on slides in classrooms. Finally, faculty must understand that some in-class assignments or activities may be more challenging to students with ADHD and they may need more on-task guidance.

So just encourage the instructors to be creative in their techniques or maybe ask students for feedback about what their learning styles or needs in the beginning…*Try to find out from the students their opinions* but not one-by-one. Maybe first day of class, everybody just write down what they prefer.

For students with these educational challenges and their respective advisors, this study suggests learning about the different classroom environments on campus for the
purpose of making more informed choices about the classes they pick as they plan their
drives. That is, recognizing that if they are picking a particularly difficult class that
the physical environment is just as an important factor to consider as picking the right
professor.

That’s something that I would look into when I take my classes next semester ---
not take classes in a large lecture hall. I really don’t like it at all.

Additionally, these findings provided some various strategies used by the study
participants that other students may find useful, if they have not yet used these
themselves. These strategies include sitting in front of the room to avoid distraction,
recording class or availing the use of audiovisual technology that captures lectures
digitally, taking momentary mental rests to re-focus their minds during classes, actively
participating in class, and asking for advanced copies of lecture presentations to aid in
their note-taking and review of class materials. And most importantly, students should
be alert for possible distractions, voice these, and be an advocate for themselves by
making instructors, administrators, and planners aware of the challenges related to
ADHD and how they can be helped.

For counselors and student services professionals, this study suggests providing a
forum where students can share their experiences and learn from each other the various
strategies that can be employed as they encounter difficulties in their physical learning
environment.

And I would like for them to maybe listen to some options from what students
might benefit from. From a range of students, too, to see what commonality
everybody is talking about. I’d like to know what somebody else, or what other
people have said that clicks with me. Then because it’s validating. It’s very
helpful to not be so hard on yourself because that happens.
I don’t know if you’re permitted to answer this question or if the answer is available, but it would be interesting to know just the ballpark number or percentage of students that are currently experiencing ADHD and is there a voluntary group that they can attend and meet each other and find out, like “oh my goodness, you have this, what do you do to learn better?”

Finally, although not directly related to the environment, one finding has implications that are unique to students with ADHD and their advisors. For most students who are taking ADD or ADHD medications, their class performances can be tied to the time of day when their ADD/ADHD medication is most effective, thus affecting the students’ peak mental performances. In addition, a common side effect of ADHD/ADD medication is suppression of appetite while the body metabolizes the drug. This means after its metabolism, which is normally towards late afternoon or evening, the student will be hungry and tired, and would thus need not only sustenance but physical and mental rest as well. Therefore students and their advisors should take into consideration when these peak and wane times occur in planning the student’s schedule of classes. Care should be taken to see that classes that need the most focused attention are scheduled during the student’s peak times. Less mentally taxing classes should be scheduled during wane times, if not altogether avoiding scheduling any classes during those wane times.

To conclude, environment has an impact on the learning experiences of students with ADHD; and they appear to be very aware of this. Their struggles to fit into spaces that are designed for the general population of students are real and have in some instances potentially negative effects on their academic success. Broadening the conversation to include this specific population of students in terms of space,
curriculum, and schedule planning could help ensure that they are not marginalized for academic success.

…I feel that a lot of students with ADHD are very diverse neurologically and we have a lot to share because we have a different way of thinking and approaching or solving problems. And I feel that things are not provided for us that way because it’s used to a standard way of people being taught and so because of that, it’s very hard to be creative or to share those differences with the campus. It doesn’t allow students with ADHD to perform to the best of their ability because they are too busy trying to focus on the standard way of education.

I would just ask or suggest that if you’re thinking about redesigning the classrooms or the buildings, you want to think of everyone who’s affected, everyone who will be in this classroom. Not just the physically disabled and the regular students but the people with disabilities that you can’t see. Rooms to be more inclusive. So just sort of think about the way it’s designed, the way people are naturally inclined to experience the building. Like what their social constructs have caused them to think what’s sort of natural.

This is one of the invisible disabilities and they’re just as much as disabilities as anything you can see. And it needs to be valued at that.

**Recommendations for Future Studies**

As stated earlier, this study can be considered as an additional starting point on the discussion of the impact of physical instructional spaces on the learning experiences of college students with ADHD. Future research may include a longitudinal study of college students with ADHD as they adapt to the rigors of higher education to see whether factors that helped or hindered their learning earlier in their academic careers continue to have the same effect as they mature academically over time. Another could be a deeper study on whether there are relationships between student grades and academic performance of students with ADHD and those positive and negative factors identified in this study. Another possible area is a comparative study of college students with and without ADHD to examine whether similar themes will surface in both groups, thus broadening the conversation on the impact of space to learning. Lastly, this
research suggests an extensive study on the relationship of the use of technology in classrooms and the academic performance of students with ADHD. Such a study would inform not only campus planners and administrators, but technology developers as well.
References


Hillsdale, New Jersey: Lawrence Earlham Associates.


