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THE EFFECT OF THE BUILT ENVIRONMENT ON OCCUPANT PERCEPTION IN
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ABSTRACT

Understanding how the built environment can influence occupant's mental health is critical when designing buildings. This is especially important for buildings where users will spend up to seven hours of their time every day (Sparks, 2020). Adolescent aged students have rapidly increasing rates of declining mental health. Blakemore (2018) talks about how many people discredit the adolescent when in reality the adolescent stage is one of the most formative time for brain development. Understanding how an educational environmental setting can influence the mental health of its adolescent occupants is of prime importance to the prevent future onset of depression or mental illness.

As indicated in by Dannenberg et al. (2011) in Making Healthy Places mental health can be defined as "A state of well-being in which the individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community," (Dannenberg et al., 2011, p. 387). A research gap analysis was conducted to identify the problem associated with environmental influence on mental health of indoor occupants that has not been addressed adequately in past literature. This goal of this study is to analyze the influence of indoor environmental parameters, such as color, light, and connection to nature on an adolescent's mental health in an educational setting. The study will identify ways for designers to create the feeling and attachment of place for occupants within an educational setting. Giving the students a chance to develop a relationship with the building should help with creating a healthy and productive environment.

This qualitative research study has adopted mixed methods of surveys, interviews, and case study analysis. The data collection method started with a survey of recent high school graduates. Upon the completion of the initial survey, the study focused on a one-on-one

interview with a designer from the renovated case study. A case study analysis was performed to study the high school building that went through an indoor environmental upgrade as indicated by the interview participants. A further look into the environments lead to design suggestions that could improve the environment towards creating positive influences on mental health.

Keywords: Mental Health, Adolescents, Education, Interior Design, Built Environment, Lighting Design, Color Theory, Biophilic Design, Depression, Anxiety, Indoor Environment Parameters, Daylighting

CHAPTER I: INTRODUCTION

BACKGROUND OF THE STUDY

High school is something that most everyone will experience. That does not make the experiences equal though. The experience that adolescents face through their schools leaves lasting impacts on them. In 2018 the United States had the largest high school graduating rate at 83% (Lee-St. John et al., 2018). That leaves 17% of adolescents who are not graduating with their class. Some of the reasons students wont graduate could be that they recently moved, disinterested in education, teen pregnancy, family responsibility, or an absence of support (Bradley, n.d.). In a study done by Rumberger and Rotermund (2012), they concluded that there is no one reason why a person doesn't finish school. It is a path that is caused by the combination of many events like the ones listed above (Rumberger & Rotermund, 2012). When a person leaves school, they are more likely to experience negative effects, like physical health and social aspects, than someone that completed high school (Lee-St. John et al., 2018). This is because there is a lack of support systems for high school dropouts. They typically have to fend for themselves without aid from any outside source (Lee-St. John et al., 2018). Out of this drop out percentage, 20% of students will drop out of high school due to issues with mental health (Serani, 2021).

Mental health is a rapidly growing issue in the world, the United States specifically (NAMI, 2021). Around 38% of the United States population struggles with a mental health disorder (NAMI, 2021). 16.5% of the youth population (6-17 years-old), which equates to 7.7 million children, have/will experience mental health issues before they graduate high school (NAMI, 2021). In a study conducted by Bor et al. (2014), they compared the rate of mental health problems in adolescents between the 20th and the 21st centuries. Their study showed an

increased incline of mental health issues in adolescents (Bor et al., 2014). It also showed that this increase was larger in the female population than the male (Bor et al., 2014). Another study conducted over a period of 10 years, indicated that adolescent emergency room visits caused by mental illness has doubled (Simon & Schoendorf, 2014). Currently suicide is second most common reason for death among adolescents and young adults age ranging from 10-35 years (NAMI, 2021). It is also reported that 18.8% of high school students indicate serious suicide thoughts of which about 50% are a part of the LGBTQ+ community (NAMI, 2021).

From ages 5-18 most of the children in American spends 7 hours in the same building, same rooms, and same desks for 180 days a year. They're with the same people and become engrossed into this routine that resets either at the new semester or school year. Students are in school for around 1,200 hours (7-hour school day times 180-day school year) of their year (Sparks, 2020). Someone that works fulltime spends around 2,000 hours (40 hours a week times 52 weeks in a year) at their job. Being a student is an occupation for these adolescents. When looking at what going to school means to adolescents, there are different responses. The two major reasons that stand out the most are 'to eat' (Gallegos et al., 2014) and 'to escape' (Lloyd, 2018). Though high school may be just a requirement for some students, but for many it is a way to their hope for a brighter and better future, forgetting about the struggles of today.

Roughly 22 million children will rely on their meals from school to feed themselves (Lentz, 2020). Weinreb et al. (2002), found that school aged children that are forced to go hungry are twice as likely to develop anxiety than children with food. Another study concluded that someone experiencing hunger at a young age will have an increased risk of developing depression in adolescents stages of life than others (McIntyre et al., 2013). Some students, typically coming from an abusive household, seek school as a safe space for themselves.

Domestic abuse influences stronger feelings of depression, self-blame, and anxiety among adolescents and young adults (Lloyd, 2018).

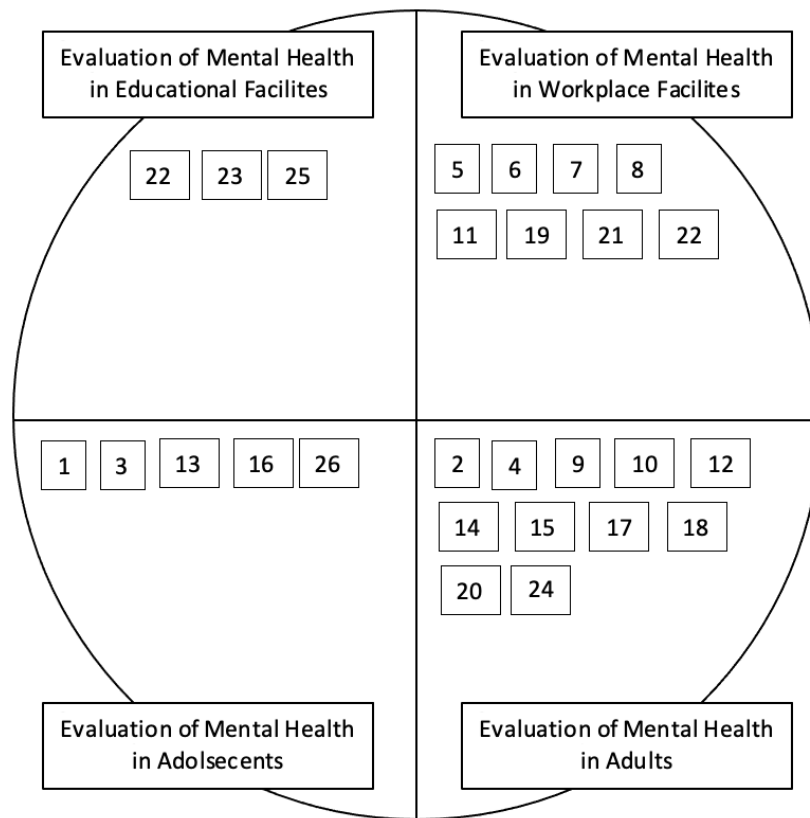
It is important for interior designers to understand how the built environment can influence or affect these young minds. Blakemore (2018) talks about how many people discredit the adolescent when in reality the adolescent stage is one of the most formative time for brain development. This is the age when children start to look further beyond their current life than they have ever done before and also start questioning topics they have never considered before. As indicated in past literature, the built environment has a strong influence on occupant's behavior and psychological needs. Understanding how an educational environmental setting can influence the mental health of its adolescent occupants is of prime importance to the prevent future onset of depression or mental illness.

RESEARCH PROBLEM

This study looks at how interior designers can influence positive mental health in adolescents through the design of the educational built environments. As indicated in by Dannenberg et al. (2011) in *Making Healthy Places* mental health can be defined as “A state of well-being in which the individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community,” (Dannenberg et al., 2011, p. 387).

A Research Gap Analysis was conducted to identify the problem associated with environmental influence on mental health of indoor occupants that has not been addressed adequately in past literature. A total of twenty-six scientific and academic journal articles published in the last 10 years were reviewed and grouped into four different categories: evaluation of mental health in educational facilities; evaluation of mental health in workplace

facilities; evaluation of mental health in adolescents; and evaluation of mental health in adults. Sources were pulled from the University of Oklahoma Library Database and Google Scholar. Articles were excluded from the analysis if they were older than ten years or did not focus on mental health in the built environment. While nineteen articles discussed about mental health in the workplaces among adults, only eight articles focused on mental health in adolescents and educational environments.



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Figure 1: Gap Analysis

As evident in Figure 1 above, there exists a large gap between the number of studies focusing on mental health in educational facilities versus mental health in the workplace environment. Though mental health consideration for workplace environment is an important aspect, it is time that designers and researchers focus on supporting mental health through the built environment of users from a younger age. Copeland et al. (2013) found during a study that adolescents with mental health problems are more likely to continue to experience or develop more mental health problems into adulthood (Copeland et al., 2013). If designers start to design environments that support these adolescents, then it could decrease the likelihood of developing mental illnesses in the future.

Further analysis was conducted to identify the age group that was addressed in studies focusing on influence of environmental parameters on occupants in educational settings. The

identified studies focused on either general educational settings (Sullivan & Chang, 2011) or college campuses (Tseng et al., 2016). Through a thorough review of past literature, the gap analysis also revealed scant research exists which considers the impact of the built environment on adolescent mental health.

PURPOSE OF STUDY

This study analyzes indoor environmental parameters, such as color, light, and connection to nature and its influence on an adolescent's mental health in an educational setting. In the context of this study, adolescence refers to a time in a person life that is in between the child and adult stage of life (Cohen et al., 1993). The age range can be from ten to twenty years old. This paper refers to high school students mostly, with an age range of fourteen to eighteen years old, which is the peak of the adolescent span (Cohen et al., 1993).

RESEARCH QUESTIONS

1. Color and Mental Health
 - a. How can color affect a person's psychology?
 - b. Are there specific colors that are more beneficial to a person's mental health than others?
 - c. How can the application of color in education affect the mental health of students?
2. Lighting and Occupant Response
 - a. What happens to a person when they have prolonged exposure to poor lighting?
 - b. What role does daylighting play in a student's performance?
 - c. How can lighting be used to offset the causes of mental health problems?
3. Nature and Human Connection

- a. Why do humans crave a connection to nature?
- b. What are the benefits that nature can bring a person?
- c. How can biophilic principles be incorporated into classroom settings?

SCOPE OF THE STUDY

This study looked at three main factors in the built environment. The first is color and psychological effect they have. The second factor covered is lighting design and its influence on occupant response. The third and final area of study is the importance of nature and its connection to humans.

Color, as identified by previous literatures, can influence the emotions of occupants (Elliot & Maier, 2014). But what about behavior? Color is an element that is bound to be in every environment. Every piece in a space will contain some aspect of color which defines the characteristics of that space. It is important for designers to have a completely understanding of the role that a particular color plays in the space. This study worked towards understanding these effects greater. Having an in-depth knowledge about the influence of color on human behavior will aid in understanding how it can be adequately used to manipulate occupants on a psychological level. This research looked to understand how color can be applied in a way that will positively affect occupant's health. Designers can then take the findings and implement them into in any space.

Similar to the color palette of a space, lighting design can also greatly influence its occupants in a space (Katabaro & Yan, 2019). It can encourage or hinder productivity of people using the space. Lighting is a major factor for occupant response because of its power to shape the perception and mood of users. Hence, it is vital for designers to understand how to use lighting to aid user's performance in space. Concepts of color theory can be applied for proper

lighting design of any environment. This study explored the color of interior lighting in addition to the other lighting parameters. Considering all of the factors (like light direction, temperature and lamp type) increases the insight designers have towards lighting design. The study investigated how designers can control the occupant response through lighting design. This added knowledge will serve as an aid to designers looking to accomplish this.

Biophilic design is similar to color and lighting in the fact that it can influence occupant's behavior and performance. Humans have a strong need to connect with nature in some way (Ryan et al., 2014). Through the addition of biophilic elements into a space, designers can successfully create that connection with the nature for the occupants. As indicated by researchers, the interior connection to nature is an essential part of positive mental health for occupants (Ryan et al., 2014). Hence it is important to include nature into the design for educational settings. This connection to nature is not just important for any educational setting, but specifically for spaces where exterior views are not permitted. With the increase in classroom sizes and larger demand for spaces, exterior windows in every classroom are a challenge for today's classroom design. Thus, biophilic design can provide the factor of nature for the occupant in those space without any exterior opening, to support and create that needed connection.

Many children are forced into these facilities that are completely that do not supportive the occupants. These inadequate designs are taking a toll on the mental health of the users. If there are design features that could elevate this issue for people, then they must be uncovered. Interior design is a profession that is in the human services division. Designers are meant to help and provide users with their needs.

METHOD

This qualitative research study adopted a mixed methods of surveys, interviews, and case study analysis. The data collection method started with the survey of recent high school graduates about their high school environment and its influence on occupants. Based on the results of the initial survey, the study identified a local high school which went through renovation recently for case study analysis. The study focused on a one-on-one interview with the designer who worked on the local high school selected as the case study building. Through in-depth analysis of the indoor environments, leads to design suggestions that could improve the environment towards creating positive influences on mental health.

SIGNIFICANCE OF STUDY

This study investigated the influence of built environment on adolescent mental health. The result of the study provides a background to designers about the impact of the built environment on adolescent academic performance and wellbeing in terms of mental health. This helps create better designs strategies for future projects. This study aids designers in their creation of supportive educational facilities for students. Developing these educational spaces that support positive mental health could influence the lives of many adolescents.

LIMITATIONS

This study had a few limitations including the limited social interaction due to the pandemic. One-on-one interviews had to be conducted virtually. The other limitation was the shorter time frame as this study spanned across five months. This does not give as much time to researching as a two-to-three-year project would. A delimitation of this study was that data collected from the surveys only pertained to students who had graduated from a public or private

high school. This limited the number of participants included in the study to gather data and analyze.

CONCLUSION

In conclusion this study aims to find the interior design parameters that influence positive mental health in educational facilities. By conducting a literature review, surveying students, and a case study analysis, effective design solutions are uncovered. It is interior designers' responsibility to create healthy learning environments for adolescent students.

CHAPTER II: LITERATURE REVIEW

INTRODUCTION

This literature review will explore the topics of mental health, color theory, lighting design, and biophilic design. Each subject has section which is further broken down into three subcategories. A total of 33 articles were shortlisted and studied to get a better understanding on the subject matter. The literature was broken down into four topics. Common keywords for selecting pieces are as follows: mental health, children, adolescent, psychology, anxiety, depression, health, color theory, interior design, human-centered design, daylighting, biophilic design, and biophilic patterns.

- **Mental health:** an overview will be given, the common mental health disorders will be listed, and who is affected by mental health disorders the most will be discussed.
- **Color theory:** will look at color and how it can affect a person’s psychology, the meaning behind colors, and how interior designers apply color theory in the built environment.
- **Lighting design:** an analysis of the physical effects of design and daylighting will be done. There will also be a look at how lighting can be used as a therapy method.
- **Biophilic design:** an overview of biophilic design is given. A discussion over humans and their connection to nature is also provided. The principles of biophilic design will be defined.

Table 1: List of Reviewed Literature

Title	Authors
Mental Health	
Increasing prevalence of depression from 2000 to 2006	Andersen, Ingelise; Thielen, Karsten; Bech, Per; Nygaard, Else; Diderichsen, Finn

A cross-ethnic comparison of lifetime prevalence rates of anxiety disorders	Asnaani, Anu; Richey, J. Anthony; Dimaite, Ruta; Hinton, Devon E.; Hofmann, Stefan G.
Are child and adolescent mental health problems increasing in the 21st century? A systematic review	Bor, William; Dean, Angela J; Najman, Jacob; Hayatbakhsh, Reza
Mental Health Disorders in Adolescents	Brookman, Richard R.
Beliefs and perception about mental health issues: a meta-synthesis	Choudhry, Fahad Riaz; Mani, Vasudevan; Ming, Long Chiau; Khan, Tahir Mehmood
Stressed Spaces: Mental Health and Architecture	Connellan, Kathleen; Gaardboe, Mads; Riggs, Damien; Due, Clemence; Reinschmidt, Amanda; Mustillo, Lauren
Mental health in the COVID-19 pandemic	Cullen, W; Gulati, G; Kelly, B D
Emergency department visits for mental health conditions among US children, 2001-2011	Simon, Alan E. and Schoendorf, Kenneth C
Mental Health and the Built Environment	Sullivan, William C. and Chang, Chun-Yen
Lifestyle and mental health.	Walsh, Roger
Depression and other common mental disorders: global health estimates	World Health Organization
Color Theory	
Impact of Interior Colors in Retail Store Atmosphere on Consumers' Perceived Store Luxury, Emotions, and Preference	Cho, Ji Young and Lee, Eun-Jung
Interior Color and Psychological Functioning in a University Residence Hall	Costa, Marco; Frumento, Sergio; Nese, Mattia; Predieri, Iacopo
Seeing red: Quality of an essay, color of the grading pen, and student reactions to the grading process	Dukes, Richard L. and Albanesi, Heather
Color Psychology: Effects of Perceiving Color on Psychological Functioning in Humans	Elliot, Andrew J. and Maier, Markus A.
Colour in interior design	Haller, K
Colour psychology and colour therapy: Caveat emptor	O'Connor, Zena
An interior design exhibition: An assessment of color scheme preferences and the emotional states of students	Uluçay, Nilay Özsvağ
A cross-cultural analysis of symbolic meanings of color	Yu, Hui-Chih
Lighting	
Unweaving the human response in daylighting design	Andersen, Marilyne
Bright Light Therapy: Seasonal Affective Disorder and Beyond	Campbell, Philip D.; Miller, Ann M.; Woesner, Mary E.
A Review of Daylighting Strategies in Schools: State of the Art and Expected Future Trends	Costanzo, Vincenzo; Evola, Gianpiero; Marletta, Luigi
Effects of Lighting Quality on Working Efficiency of Workers in Office Building in Tanzania	Katabaro, Justine Mushobozi and Yan, Yonghong
LED-technologies for bright light therapy	Kukhta, M. S., Sidorenko, E. V., Simutkin, G. G., Khomushku, O. M., & Glushkov, G. S.

Effect of daylighting on student health and performance	Mirrahimi, Seyedehzahra; Ibrahim, NL Nik; Surat, M
Physical characteristics of the indoor environment that affect health and wellbeing in healthcare facilities: a review	Salonen, Heidi; Lahtinen, Marjaana; Lappalainen, Sanna; Nevala, Nina; Knibbs, Luke D.; Morawska, Lidia; Reijula, Kari
Adjunctive bright light therapy for bipolar depression: a randomized double-blind placebo-controlled trial	Sit, Dorothy K; McGowan, James; Wiltrout, Christopher; Diler, Rasim Somer; Dills, John; Luther, James; Yang, Amy; Ciolino, Jody D; Seltman, Howard; Wisniewski, Stephen R
Efficacy of bright light therapy in bipolar depression	Yorguner Kupeli, Nese; Bulut, Necati Serkut; Carkaxhiu Bulut, Gresa; Kurt, Emel; Kora, Kaan
Biophilic Design	
Returning to my trees: Connection to nature, wellness and clinical practice	Brubaker, Laurel E
The practice of biophilic design	Kellert, Stephen and Calabrese, Elizabeth
Biophilic design: the theory, science and practice of bringing buildings to life	Kellert, Stephen R; Heerwagen, Judith; Mador, Martin
Biophilic Design	Ryan, Catherine O. and Browning, William D.
Biophilic Design for Restorative University Learning Environments: A Critical Review of Literature and Design Recommendations	Peters, Terri and Penna, Kristen

REVIEW OF LITERATURE

MENTAL HEALTH

Overview

Several factors can influence mental health in a person. In a study conducted by Roger Walsh (2011), eight different TLCs (therapeutic lifestyle changes) were tested to understand their impact on a person's mental health. It was found that introducing positive TLCs, such as more exercise/activity or better nutrition/diet, had positive effects on their physical health and mental health (Walsh, 2011). This study also investigates other factors influencing mental health. Walsh (2011) highlights how so many of people's day-to-day activities can impact their mental health.

The built environment is one of the other areas that influences a person's mental health. In a book written by Sullivan and Chang (2011), they found that specific interior parameters

affect humans differently. Crowded places will often provoke a feeling of distress and anxiety. When noisy or loud spaces are undesired by users, such as schools or workplaces, it can create unnecessary psychological distress. Sullivan and Chang (2011) point to this being why children living in multifamily housing communities have increased levels of anxiety and depression. Inadequate lighting and lack of natural views in task-completing built environments, e.g., schools or workplaces, increases mental fatigue in occupants. The increase in mental fatigue increases the chance of developing a mental health disorder. Additionally, poor wayfinding in a building can cause an increase of stress on a user (Sullivan & Chang, 2011).

Another study by Connellan et al. (2013) covered a similar topic as the previous article but from the view of healthcare and rehabilitation centers and their interior parameters. The parameters or themes in *Stressed Spaces: Mental Health and Architecture* (Connellan et al., 2013) that stand out in this article were security, light, therapeutic milieu, and adolescents. When looking at the theme of security, researchers found that overcrowding in spaces can lead users to lose some of that sense of security (Connellan et al., 2013). Like previously mentioned, that overcrowding helps lead to psychological distress (Sullivan & Chang, 2011). In the discussion of the second theme, Connellan et al. (2013) found that controlling a person's circadian rhythm depends on light, whether it be natural or artificial. When someone's circadian rhythm is unbalanced, it can contribute to insomnia, depression, heightened agitation, and eating patterns (Connellan et al., 2013).

Finally, therapeutic milieu is a design that centers around the patient and healing (Connellan et al., 2013). The study found that occupants have higher restoration rates, decreased stress, and increased attention when the therapeutic milieu is incorporated into the design. All these elements are essential to keeping mental fatigue at a minimum. Examples of therapeutic

milieu are interiors that focus on human interaction, spirituality, human touch, and healing arts. (Connellan et al., 2013). When studying how adolescents differ from adults, they highlighted a need to keep adolescents connected to the outside world. Maintaining this connection is vital, so adolescents don't feel uninvolved or locked away (Connellan et al., 2013).

Mental Health Disorders

Common mental health disorders (CMHD) can be defined as the two main diagnostic categories: anxiety disorders and depressive disorders (Organization, 2017). Each category has a variety of disorders; however, for this research, the following listed are most common among the adolescent age. These anxiety disorders are generalized anxiety disorder (GAD), social anxiety disorder, panic attacks, obsessive-compulsive disorder, and post-traumatic stress disorder. Depressive disorders also referred to as mood disorders, include adjustment disorder with depressed mood, major depressive disorder (MDD), bipolar disorder, premenstrual dysphoric disorder, and seasonal affective disorder (SAD) (Brookman, 2017).

Anxiety disorders are identified by the experience of fear or anxious feelings. These disorders can range from being mild to severe and typically is a chronic condition, sticking with those affected for a large portion of their lives (Organization, 2017). The World Health Organization (2017) describes mood disorders as loss of pleasure/interest, increased sadness, irregular sleep/appetite, feelings of guilt, low self-esteem, and lack of concentration. Depressive disorder can last from weeks to months, and in some cases, it can become reoccurring. These disorders can hinder a person's ability to function day-to-day (Organization, 2017). It was also found that many people with a CMHD will have a comorbidity with another CMHD. For example, a person suffering from MDD might develop social anxiety disorder from the mood disorder (Organization, 2017).

Who is being affected?

According to Choudhry et al. (2016), one in four people is affected by a mental disorder in some capacity. When scaling that down to just adolescents (18 years and younger), this becomes one in five with a mental health disorder Color. In fact, Simon and Schoendorf (2014) detected that in ten years (2001 – 2011), mental health emergency room visits in children and adolescents had doubled. When looking at the comparison of age groups, the adolescent range had a higher visit rate than the children age (Simon & Schoendorf, 2014)

A Cross-Ethnic Comparison of Lifetime Prevalence Rates of Anxiety Disorders (Asnaani et al., 2010) analyzed anxiety disorders and their appearance in four different racial groups (African Americans, Asian Americans, Hispanic Americans, and White Americans). It was found that White Americans are more likely to experience generalized anxiety disorder, social anxiety disorder, and panic disorder than the other three groups. Meanwhile, post-traumatic stress disorder is found in African Americans more than the three (Asnaani et al., 2010). Bor et al. (2014) also found that adolescent girls are more likely to develop an anxiety disorder than adolescent boys.

In a study conducted by Andersen et al. (2011), it was found that MDD has been increasing two to four percent each year since 2006. It was also recorded that the number of women developing mental health issues is about double the number of males (Andersen et al., 2011). COVID-19 has created a drastic increase in mental health issues. A recent study asked 1210 people if they have had a psychological impact from COVID-19. Around 30% of responders said they had increased feelings of anxiety, and 17% said an increase in depressive moods. Over half of these responses rated the feelings as moderate to severe (Cullen et al., 2020).

COLOR THEORY

Connection between Color and Psychology

The work of Johann Wolfgang von Goethe pioneered the study of human psychology and its connection to color (Elliot & Maier, 2014). Goethe was a German poet and polymath. Around 1810 he introduced the ideas of ‘plus colors’ and ‘minus colors’ off an intuition that he had. The warm colors, like yellow or red-yellow, were ‘plus colors’ and had positive emotions attached to them. Some of the listed attributed emotions were liveliness, aspiring, and warming. While ‘minus colors’ were the cool colors, such as blue and violet, and had more negative emotions attached to them. The associated feelings here were restlessness, coldness, and anxiousness (Elliot & Maier, 2014).

Slowly more and more researchers started to investigate this topic. New connections were made, and the colors began to gather unique attributes. Until the twenty-first century, the study was purely theoretical because of its various colors. Hues, lighting, chroma, and printing can all change the way a color appears and were all around too inconsistent with testing. There are now different methods that researchers are using to test these theories. The most common ways are to use computers through the Natural Color System program and spectrophotometers to keep consistency across studies. This way aids in keeping data collection as accurate as possible (Elliot & Maier, 2014).

Various studies have been done looking at psychological functioning. Elliot and Maier (2014) broke these studies into two sections: competitive sports and individual cognitive and motor performance. In the section on competitive sports, it was consistently found that when teams/athletes used red as the primary color in their uniform had higher performance rates than those that focused on other colors; for example, a team that’s primary color is blue (Elliot &

Maier, 2014). Elliot and Maier (2014) looked from team to individual sports, from contact to card games. Even using red chips in poker gives the player a higher chance of winning. Their findings concluded that red influences the opponent to see their competitor in a more dominant, assertive, and intimidating way (Elliot & Maier, 2014).

When the authors focused on color in individual cognitive and motor performance, their results were different. They also studied color and academic performance, wherein red was found to be linked with failure, danger, and over-stimulation (Elliot & Maier, 2014). One study showed that when grading papers, feedback in the color blue was received stronger than markups in red among students (Dukes & Albanesi, 2013). Dukes and Albanesi (2013) found that because students had negative connotations with red, they immediately interpreted the grading as being told they were wrong. The blue ink was interpreted as more of a suggestion and an indication of how they could improve (Dukes & Albanesi, 2013). Classrooms with blue and green pallets showed greater creative performance than other colors (Elliot & Maier, 2014).

In another article by O'Connor (2011), the color-chakra theory was brought to light. The idea of the chakras began from Hindu beliefs. The chakras are said to be the energy hubs in the body. This is a theory based on linking a color to one of the seven chakras in the body. This is meant to explain the different functionalities of the body (O'Connor, 2011). O'Connor (2011) gives the following examples of the color-chakra theory. Red controls the body's circulation system and the five senses. It can be used to help with colds, anemia, and other blood-related conditions. Green is linked with the strengthening of the bones and muscles. It can relate to disinfecting bacteria and elevates stress and tension. The last example O'Connor (2011) gives is the color blue. Blue heightens a person's metabolism. It can also balance out the heart,

bloodstream, and muscles. Blue is used to treat burns, skin diseases, and throat issues (O'Connor, 2011).

Colors and Their Meanings

In *A Cross-Cultural Analysis of Symbolic Meanings of Color* by Hui-Chih Yu (2014), they analyze the meaning behind the three primary colors and white and black. Each color comes with both positive and negative meanings. Starting with the positive connotation with red. It can symbolize warmth, protection, influence, and life. It is often seen in connection with love, happiness, and fortune. Chinese culture is heavily centered around this color because of its positive relation to red. Some of the negative symbolism of red can be blood, sin, and war (Yu, 2014). The color yellow symbolizes heaven, renewal, humility, and wisdom. It is a luminous color that typically encompasses happiness. On the other hand, it can mean disease, aging, and deceit.

Moving into looking at the meaning behind blue. Blue is color has positive implications like peace, truth, stability, and conservatism. Blue has a strong negative relation to depression, loneliness, and isolation. It is often linked to suicide (Yu, 2014). Turning to the positive connotations with white. Yu (2014) talks about how white has a meaning of purity, innocence, and glory. White is a commonly used color in Christianity because of its meaning. Negatively white is associated with lifeless, paleness, and sometimes treachery. The last color, black, is often recognized with its negative connotations of death, fear, and the unknown. But that doesn't mean that the color doesn't have any positive meanings. It can represent rebirth, resurrection, and time (Yu, 2014). The rise of artificial dyes has increased the spread of color cognition. Understanding how other cultures interpret colors can have lasting effects on a design. If a

designer does not appropriately consider the meaning of colors, their design can become something they did not intend (Yu, 2014).

Color Theory in the Built Environment

Color is a crucial parameter of interior design. This is because of its solid connotations and ability to influence occupants both physically and psychologically (Uluçay, 2019). Haller (2017) discusses how effectively applying color theory to an environment an interior designer can create spaces that meet the occupant's needs. When color is not entirely considered, it can lead to interiors that work against the intended goals of the occupants (Haller, 2017).

There are also several factors that alter the perception of color. Haller (2017) describes the three major ones as light, texture, and climate. Lighting comes in two forms, artificial and natural. Natural light is a constantly changing source, meaning the look of a color will be subject to what is available on that day. Depending on what artificial lighting is specified will also change the way a color appears. Designers need to consider the color temperature, the brightness, and highlights/shadows produced with artificial lighting (Haller, 2017). Textures create visual contrast amongst themselves; this leads the eye to perceive objects differently. Colors will appear to be lighter on smooth textures, while rough textures create a darker look. Rough textures absorb light, and smooth textures will reflect (Haller, 2017). Latitude, hemisphere, and season all play into climate as well as color. Places that are closer to the poles will see colors in cooler tones. Colors more immediate to the equator will come across as warm (Haller, 2017). Designers must understand how these factors will affect a space and consider the changes to the visible color (Haller, 2017).

To physically test this subject, Uluçay (2019) decided to assess what students' color preferences are in the classroom. The researcher questioned 48 students. The age range was from

18 to 30 years old. The participants were shown the same interior in 12 different color schemes and asked to rank them based on which they favored the most (Uluçay, 2019). The data that Uluçay (2019) collected showed that this aged group of students wanted yellow and blue colored classrooms and preferred muted tones and complementary color schemes (Uluçay, 2019).

In a similar study by Costa et al. (2018), looking at college resident halls, the preference for blue was strong here as well. This study took 443 and split them between six different buildings. Each building was designed in a different color. The results of this study showed that resident halls with a blue interior had the highest productivity rate and relaxing mood. The buildings with red and orange interiors had the lowest productivity and were perceived as too harsh by occupants (Uluçay, 2019).

LIGHTING DESIGN

Effects of Lighting on Humans

Lighting in an interior space can have both physical and psychological effects on the human body. Similar to color, the effect lighting has on a person depends on many factors. Poor lighting often leads to visual discomfort. When visual comfort occurs, occupants complain of higher feelings of anxiety, fatigue, unable to concentrate, etc. (Katabaro & Yan, 2019). Fixture position/height, illuminance level, color, luminaire type, and quality can all play a role in how a person comprehends the space (Katabaro & Yan, 2019). For example, bright artificial light that mimics natural light in healthcare is connected with decreasing depressive moods. However, this same type of lighting in a counseling facility makes occupants feel exposed and crowded (Salonen et al., 2013).

In a workplace setting, when the proper lighting level is given uniformly, there is an increase in the mood and concentration of users. This increase in mood and concentration caused

productivity to improve (Katabaro & Yan, 2019). It is crucial for designers to consider the correlated color temperature (CCT) and the color rendering index (CRI) as both control how light is observed in an interior. The CCT of light impacts visual perception. This is linked with satisfaction, occupant mood and comfort, and cognition (Katabaro & Yan, 2019). Katabaro and Yan (2019) state, “applying appropriate CCT in the working environment enhances occupants’ motivation, improves health and cognition, increases working efficiency, and hence improves productivity” (Katabaro & Yan, 2019).

In two different studies, conducted by Salonen et al. (2013) and Katabaro and Yan (2019), results showed an increase in satisfaction, motivation, and comfort when the occupants were given control over their lighting levels (Katabaro & Yan, 2019; Salonen et al., 2013). Chartered Institution of Building Services (1994) suggests that when occupants are not given this autonomy, discomfort and stress will have a greater chance of growing (Chartered Institution of Building Services, 1994).

Katabaro and Yan (2019) found in their research that most office spaces had issues with at least one of the following: glare, flickering, or buzzing. These characteristics of lamps could negatively influence occupants’ visual comfort. Glare directly affects a person’s vision by causing irritability, distraction, and mental and physical tiredness. When a lamp starts to buzz or flicker, it creates another area of irritability and distraction. Discomfort, eyestrain, and headaches are shared among users and will be present until the lamp is replaced (Katabaro & Yan, 2019).

Daylight

Daylight is viewed as one of the most critical parameters in the built environment. It can be one of the most prominent influences in a space. Daylighting is a free, renewable resource (Mirrahimi et al., 2013). Natural light provides occupants with healthier interiors. It directly

exposes users to vitamin D, which helps with calcium absorption. A vitamin D deficiency could result in abnormal bone development (Mirrahimi et al., 2013). Another health aspect that benefits from natural light is a person's circadian rhythm. When a person's access to natural light is weakened, it disrupts the rhythm in which Melatonin is released. This can lead to fatigue and depression (Mirrahimi et al., 2013).

When an interior is designed with the thought of daylight, then students' mental health and visual comfort are both increased (Mirrahimi et al., 2013). Daylighting has been proven to positively affect a student's health, psychology, and learning achievements. The absence of natural light has been linked with developing stress and depression. A person needs at least three hours of exposure to daylight to combat this (Mirrahimi et al., 2013).

Eight thousand students were placed into 450 different classrooms. Half were placed in classrooms with natural light and exterior views. The remaining participants were placed in artificially lit classrooms. When analyzing the test scores, the scores from the daylit classroom are up to twenty percent better than the ones with no lighting (Mirrahimi et al., 2013). In another, over 21,000 students from Fort Collins, California, and Seattle were tested over their academic performance. The results showed that students in California learn information twenty to twenty-six percent faster when there is a constant presence of natural light compared to Fort Collins and Seattle (Mirrahimi et al., 2013).

In *Effect of daylighting on student health and performance*, Mirrahimi et al. (2013) points out that daylighting is such an essential influential parameter in a student education facility design. Yet, it is most commonly found to be inadequate even though daylighting is a topic that has been discussed since the 19th century, Costanzo et al. (2017) shares that architects rarely

considered this as a basic need for the environment and more as an add on (Costanzo et al., 2017).

Lighting as a Therapy Method

Lighting can serve as a therapy method because it can change both humans' physical and mental health. As mentioned, the circadian rhythm is controlled by the natural light a person receives. When that is disturbed, someone can experience a non-24-hour sleep-wake disorder. This disorder can then lead to more severe issues such as insomnia and diabetes. It has been shown that when people are exposed to blue-enriched white light throughout the day, the occupant's performance, mood, and sleep quality all improve (Andersen, 2015).

Seasonal Affective Disorder (SAD) is a type of mood disorder. It is described as a depressive episode during the fall and winter seasons. As spring and summer come along, the mood is uplifted just to start the cycle in the fall. The leading cause of this disorder is the decreased amount of natural light is received. To treat SAD, many people use Bright Light Treatment (BLT). The most common approach to this is exposure to 10,000 lux for 30 minutes (Campbell et al., 2017). In a four-week study over the effectiveness of BLT against SAD, sixty-one percent of participants had a fifty percent decrease from their initial score from the Structured Interview Guide for the Hamilton Depression Rating Scale (Campbell et al., 2017).

Bipolar disorder is described as a type of mood disorder when a person experiences recurring depressive episodes. Despite the evolution of other treatment methods for mood disorders, bipolar disorder does not have a straightforward approach (Yorguner Kupeli et al., 2018); because bipolar follows a similar path as SAD many researchers are looking into using BLT as a treatment method. In one study, over sixty-five percent of participants with bipolar disorder reached remission after six weeks of BLT (Sit et al., 2018). In another study, two-week

study forty-four percent of participants with bipolar disorder experienced remission (Yorguner Kupeli et al., 2018). These results are promising when applying BLT to this mood disorder.

Kukhta et al. (2018) studied whether overhead LED light panels could be used as an option for light therapy. LED lights can fluctuate their illuminance. The light panels would be set on a sensor and raise the light levels to 10,000 lux for 15-60 minutes of the day (Kukhta et al., 2018). One of the findings was that depending on the placement of the light panels affected the person. If the retinas were not getting the direct light, then it wouldn't be successful. The researchers call for a medical review to give a conclusive answer on whether or not this would be helpful toward SAD (Kukhta et al., 2018).

BIOPHILIC DESIGN

Overview

Biophilic design is a design theory that centers the built environment around the concept of biophilia (Ryan & Browning, 2020). Biophilia can be described as the instinctual connection that humans have with nature. This is an idea that has been present throughout the entire human existence. Today's way humans live is only a recent development in time (Kellert & Calabrese, 2015). Kellert and Calabrese (2015) highlight that over ninety-nine percent of human evolution happened in natural environments. The human body, mind, and perception were formed and function in a bio-centric manner rather than man-made (Kellert & Calabrese, 2015).

Researchers have also emphasized that the rapid pace of modernization in the built environment has cut this biophilic need. The solution was to begin incorporating biophilic design into new buildings and implement 'restorative environment design' into preexisting interiors. These are defined by low-environmental-impact renovations to spaces that support the occupants' connection to nature (Kellert et al., 2011).

Connection between Human and Nature

The connection between humans and nature is a crucial aspect for functioning, health, and well-being. Supporting this connection is linked with a multitude of benefits. It increases healing from ailments, decreases social issues, increases productivity, decreases stress, and heightens concentration and memory. Children have an easier time developing in a biophilic environment and often have a happier experience. People living in biophilic communities are reported to live a higher quality of life than those surrounded by urbanization (Kellert et al., 2011). The connection to nature also leads to higher self-esteem and a sense of belonging and meaning—all three of these aid in implementing positive mental health among humans (Brubaker, 2020).

A study by Peters and Penna (2020) conducted a literature review of over 30 peer-reviewed articles to see how biophilic design was incorporated into the built environment and if it was successful. The research was based around these five theories: Restorative Environmental Design, Place Attachment Theory, Attention Restoration Theory, Stress Reduction Theory, and Prospect-Refuge Theory. These theories considered how biophilic design influences the built environment (Peters & Penna, 2020). It was shown that many universities use visual biophilic implementations such as green views, indoor plants, and green through the spaces. Another recent inclusion is the use of outdoor learning spaces since the rise of COVID-19. These settings provide the occupants with the needed environment to learn and a sense of security amongst the group (Peters & Penna, 2020).

Principles of Biophilic Design

Biophilic design can be broken down into five different principles. These principles provide a guide for designers to follow when creating interiors. Kellert and Calabrese (2015) list the principles as follows:

1. Biophilic design requires repeated and sustained engagement with nature.
2. Biophilic design focuses on human adaptations to the natural world that over evolutionary time have advanced people's health, fitness, and wellbeing.
3. Biophilic design encourages an emotional attachment to settings and places.
4. Biophilic design promotes positive interactions between people and nature that encourage an expanded sense of relationship and responsibility for the human and natural communities.
5. Biophilic design encourages mutual reinforcing, interconnected, and integrated architectural solutions.

In addition to the principle of biophilic design, there are three different experiences that a human can have with biophilic design. The first one is a direct experience. This is when there is contact with actual environmental features. Natural light, air, and plants are just some of the types of direct experiences. The second is indirect experience, meaning contact with the symbolism of nature. This can be seen in environment imagery, natural materials, or organic forms (Kellert & Calabrese, 2015). The third is the experience of space and place. This type covers spatial characteristics of human wellbeing. Wayfinding and areas of refuge are in this classification. All three of these experiences work to stimulate an occupant's five senses. When one of the experiences is missing, the effect of biophilia will not be as strong (Kellert & Calabrese, 2015).

CONCLUSION

In conclusion, the literature review provided substantial contributions towards the development of this study. Through the review, many design recommendations have come forward. From the analysis of color, it was found how color could psychologically influence the mood and feelings of occupants. The review of lighting showed the effects of poor lighting on occupants. It also presented ways in which lighting can be used to treat mental health disorders. Biophilic design was identified as a method of nurturing the connection to nature for occupants. There was a great deal of student performance mentioned in the literature found. It would be interesting to look further into how student performance relates to student mental health.

CHAPTER III: METHODOLOGY

INTRODUCTION

This chapter will discuss the methods and order of actions that have been taken during this study. This study used a mixed-method approach of surveys, interviews, and case study analysis. The data collection method started with a survey of recent high school graduates. Through the completion of the initial survey, Norman High School was identified as the building for the case study analysis as it went through design renovation few years ago. Norman High School was chosen on the number of Norman High School graduates attending the University of Oklahoma, the access to the school's location, and the connection with renovation designers. The researcher further conducted one-on-one interview with a designer involved in the Norman High School's renovation design. A case study analysis was then executed to understand the environmental parameters that went through an indoor upgrade as indicated by the survey participants. This led to a discussion over possible design suggestions that could have been adopted to improve the environmental parameters, thus positively influencing mental health.

STUDY PARTICIPANTS

The following criteria must have been met by participants of the survey analysis (1) 18 years or older, (2) graduated from high school, and (3) attended a public or private school. The sample limited the participants to high school graduates that physically went to an education facility and could complete the survey with internet access. One recruitment email was sent to University of Oklahoma students through the school's mass messaging system (OUMM).

METHOD OF CONTACT

Upon the approval of the study by the University of Oklahoma Institutional Review Board (IRB) a recruitment email was sent to all University of Oklahoma students with an URL link to the survey website. Consent was located and obtained at the beginning of the survey on the website. Survey responses were kept anonymous unless the participants were willing to give their email addresses and permission to contact them at the end of the questions.

DATA COLLECTION

The survey was created using online survey management tool. Because of the mass quantity of participants, having the survey be accessible through the internet was the most efficient choice. The OUMM system was a practical choice for reaching the most significant portion of participants. This system enables the sender to push emails to all of the University of Oklahoma's current students.

Once participants opened the URL link from the recruitment email, they were brought to the survey website. The consent agreement was the first thing that was addressed. Once the participant agreed to consent, they were asked if they were 18 years or older. If they were not, they could not continue with the survey. During the demographic section, participants had to answer which high school education they received. If the participants selected homeschool, GED, or other, they were taken to the end of the survey. From then on, all participants met the requirements and completed the survey.

SURVEY

The process of creating the survey started with the literature review. Through this research key, indoor environmental parameters were identified. This information was taken and applied to the questions of the survey. The Principal Investigator (PI) and the study contact went

through the survey several times to ensure the survey flowed properly and made sense. Once both parties approved the survey, it was published and sent to University of Oklahoma students. This survey consisted of three sections: (1) informed consent, (2) demographics, and (3) building analysis.

Section 1: Informed Consent

This section of the survey informs the potential participants with an overview of the survey, what questions will be asked, who/how they can contact, what data will be collected, and the IRB approval information. The participant must select the yes option to complete the survey. In addition, they are also asked if they are 18 years or older. The yes option must be specified here. If no choice was chosen on either question, participants were taken to the end of the survey and could not answer the questions.

Section 2: Demographics

This survey section was included to get the maximum amount of background information over the participant without relieving too much about themselves. This information proves to be helpful when comparing results across the survey. It was also crucial to know what type of high school education participants had. If they did not attend a private or public high school, they were sent to the end of the survey. Information collected here was the following:

- Age
- Race/Ethnicity
- Type of High School Education
- Year of High School Graduation
- State of High School

Section 3: Building Analysis

Here is where participants were questioned over their high school building. Questions were formed around the indoor environmental parameters of (1) lighting, (2) color, (3) connection to nature, (4) sense of place, (5) furniture, (6) thermal quality, and (7) acoustical quality. Participants were asked to rate their building based on a series of statements and whether they agreed with it using a Likert scale. The statements are as follows:

Table 1: Evaluate the interior of your high school in terms of occupant well-being. Rate your level of agreement with the statements below.

- Lighting
 - Did you find that the overall lighting in the space supported your needs?
 - Soft, warm lighting was more comforting than bright, white lighting.
- Color
 - The colors in the building supported my performance. If so, what were some of the colors used?
- Connection to Nature
 - There was an adequate number of outdoor views from classrooms.
- Sense of Place
 - Did you feel like you have a place to call your own in the building?
- Furniture
 - The furniture used in the classroom was comfortable and supported ergonomics.
- Thermal Quality
 - The thermal quality (A/C, heating, etc.) was effective and rarely was an issue.
- Acoustical Quality

- Outside noise and sounds did not affect the experience you had in a classroom.

The participants were then asked whether they attended Normal High School; if yes was selected, they were asked if they attended Norman High School during the 2015 – 2017 renovation. When selecting no, participants were asked if their high school had a renovation during their tenure. Participants selecting no on either renovation question were done with the survey and brought to the survey end. If they chose yes, they were prompted with two more Likert scale tables over their experience with the renovations and whether the renovation results were more desirable than pre-renovation. The statements used are as follows:

Table 2: Evaluate the interior of your high school in terms of occupant well-being during renovation period. Rate your level of agreement with the statements below.

- The construction from the renovations caused major changes in day-to-day functioning.
- Lighting
 - The construction had a noticeable effect on the lighting in the building.
 - The lighting in spaces suffered from the construction.
- Color
 - With the renovations, more color was introduced into the building.
- Connection to Nature
 - The renovations increased the number of outdoor views.
- Sense of Place
 - The construction affected your place attachment in a negative manner.
- Furniture

- The new furniture introduced was more supportive than previous furniture pieces.
- Thermal Quality
 - The thermal quality (A/C, heating, etc.) was increased.
- Acoustical Quality
 - The noises from construction were distracting during instruction.

Table 3: Evaluate the interior of your high school in terms of occupant well-being post-renovation period. Rate the design parameters below based on if they created a better environment post-renovation than pre-renovation.

- Lighting
- Color
- Connection to Nature
- Sense of Place
- Furniture
- Thermal Quality
- Acoustical Quality
- Overall, the post-renovations created a better environment than pre-renovations.

The participants were then asked the final questions. (1) Whether they would be willing to share the name of their high school, selecting yes would give an option to type the name. (2) If they would be willing to be contacted for further questioning, choosing yes would give a field for their email addresses. Once these questions were answered, their survey would be submitted for analysis. A complete list of survey questions is located in Appendix B.

DATA ANALYSIS

Responses to the survey were exported from the online survey management tool to an excel spreadsheet. This file was kept on a secure cloud service where only the PI and the study contact had access. Uncompleted and unqualified responses were filtered out. The data was sorted by (1) ability to contact, (2) if the participant attended Norman High School during the 2015 – 2017 renovation, (3) if the participant attended high school during a renovation, (4) age, and (5) school name. The data was then analyzed per question. Results were then used to formulate the questions for the designer interview, provide building satisfaction levels, and support information found in the literature review.

INTERVIEW

The interview portion of this study is essential when looking at the project's goals and how mental well-being among adolescent students is being considered. Contact was made with one of the designers on the Norman High School project. From the survey, questions were formed. The following topics were discussed with the designer:

- Identified renovation goals
- Identified renovated spaces
- Design process
- Research methods
- Lighting design
- Biophilic design
- Color and IEQ

A complete list of interview questions is located in Appendix C. Once the interview was concluded, the interview was analyzed. The designer's responses were transcribed and then coded according to identified themes.

CONCLUSION

Taking the information found in the literature review, results from the survey, the interview with the designer, Norman High School is analyzed in Chapter 5. The analysis considers the indoor environmental parameters of color, lighting, and the connection to nature. The areas of renovation identified the spaces studies. The sites are the learning commons, the media center, the main corridor, and the college career center. Here design recommendations are given that could increase the positive influence of mental health of adolescents are provided.

CHAPTER IV: RESULTS

INTRODUCTION

Results in this chapter were collected from an online survey and interview with a designer. The survey results were split into six different categories: (1) demographics, (2) color, (3) lighting, (4) connection to nature, (5) sense of place and ergonomics, and (6) thermal and acoustic quality. The results from the interview are transcribed and coded presented towards the end.

SURVEY

DEMOGRAPHICS

The survey had 497 responses; out of which, 406 responses were deemed to be useable— with a total of 156 participants that had experienced some sort of renovation during their duration at high school. The majority of participants were between 18 years and 24 years old at 85%. While 6% were 25 – 30 years old, 5% were 31 – 39 years old, and 4% were above 40. See figure 2. Regarding race/ethnicity, 68% selected White or Caucasian, 10% Asian or Pacific

Islander, 9% Hispanic or Latino, 6% Multiracial or Biracial, 5% Native American or Alaskan Native, and 2% Black or African American. See figure 3.

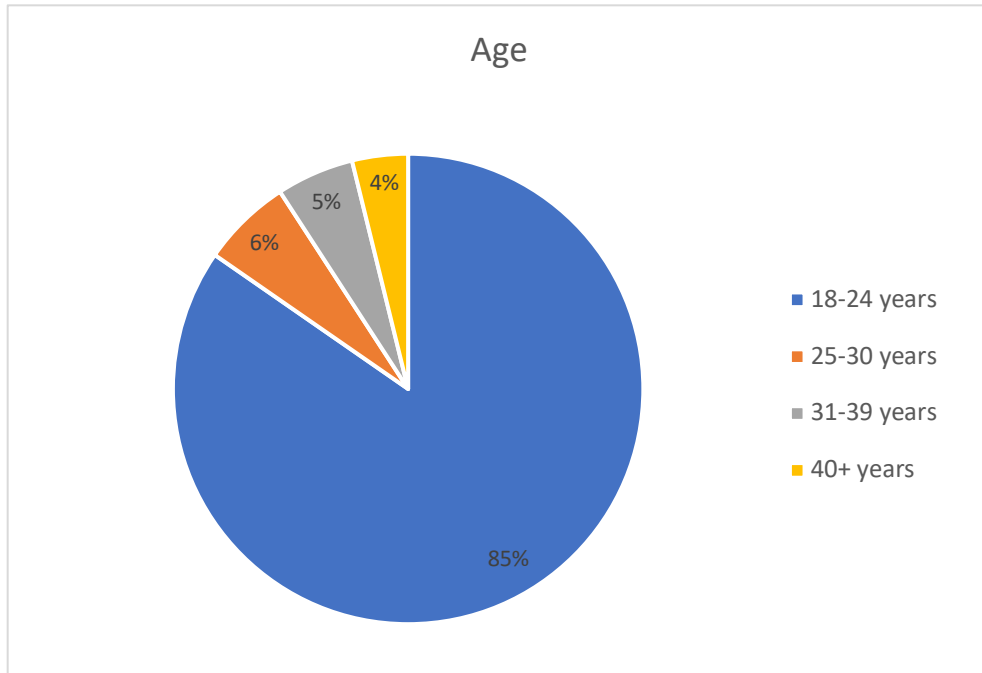


Figure 2: Age of survey participants

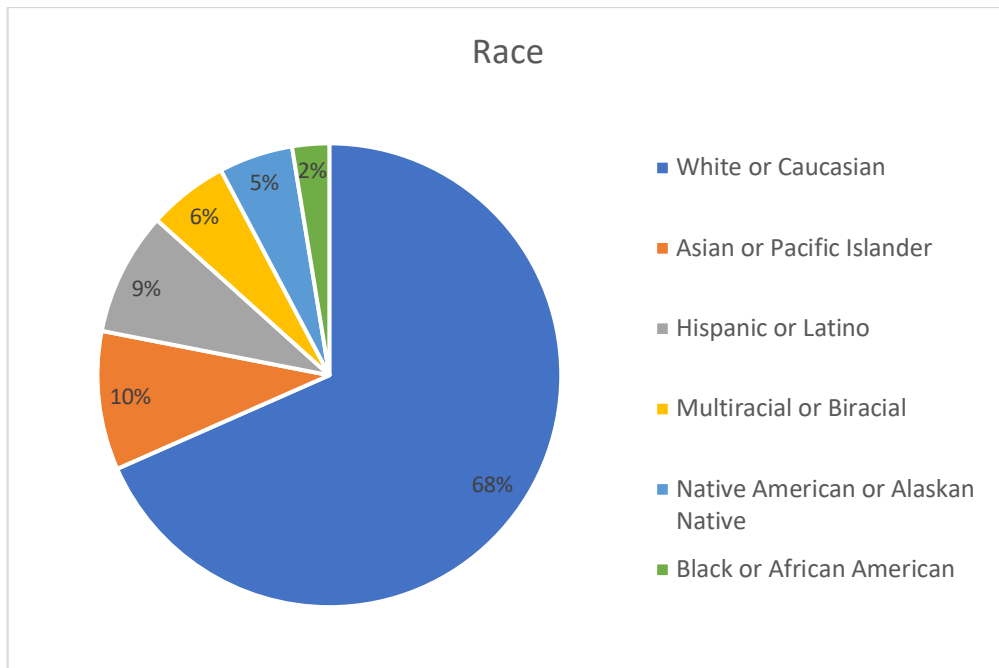


Figure 3: Race of survey participants

The most common type of high school attended was public school with 84%. Private was the second highest with 11%. 5% were homeschooled, obtained a GED, or selected 'other'; these respondents did not meet the requirements and were taken to the end of the survey. See figure 4. 62% of participants went to an Oklahoma high school. 19% went to a Texas high school, and 3% were in Kansas. 16% attended school in another state. See table 2. 372 participants, around 84%, graduated high school between 2016 – 2021.

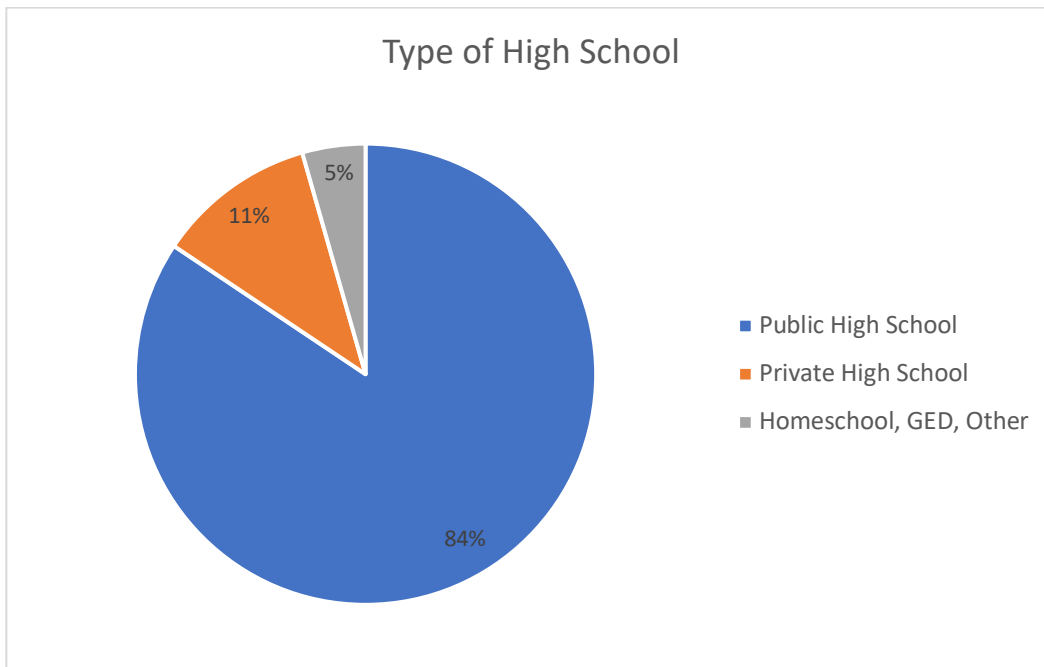


Figure 4: Type of High School attended by survey participants

Table 2: Location of the highschool attended by survey participants

State	Number of Graduates
Oklahoma	273
Texas	86
Kansas	12
Illinois	7
Colorado	6
California	6
Pennsylvania	4
Missouri	4
Arkansas	3

Florida	3
New York	3
Ohio	3
North Carolina	2
Iowa	2
Tennessee	2
New Jersey	2
Virginia	2
Wyoming	2
Indiana	2
Nebraska	2
Kentucky	1
Idaho	1
State of High School	1
Louisiana	1
Alabama	1
Maine	1
New Mexico	1
Maryland	1
Mississippi	1
Michigan	1
Utah	1
Minnesota	1
Wisconsin	1
South Carolina	1
South Dakota	1

COLOR

While most respondents said they were neutral to the colors used, 35% disagreed, and only 24% agreed with them; this came from a sum of 355 responses. See figure 5. Participants who were in agreement with the color scheme were asked to share what colors were used. White was reported in 29% of colors schemes used. Gray was used in 12% of the buildings, black and brown were used 5% of the time. Blue was the most popular hue, being mentioned 16% of the time. Red was next at 9%. Green and yellow were reported at 7% each, purple at 6%, and orange

at 4%. See figure 6. Out of 154 post-renovation responses, 53% of participants said the use of color improved, while 20% said the colors deteriorated, and 27% remained neutral compared to the building prior to renovations. See figure 5.

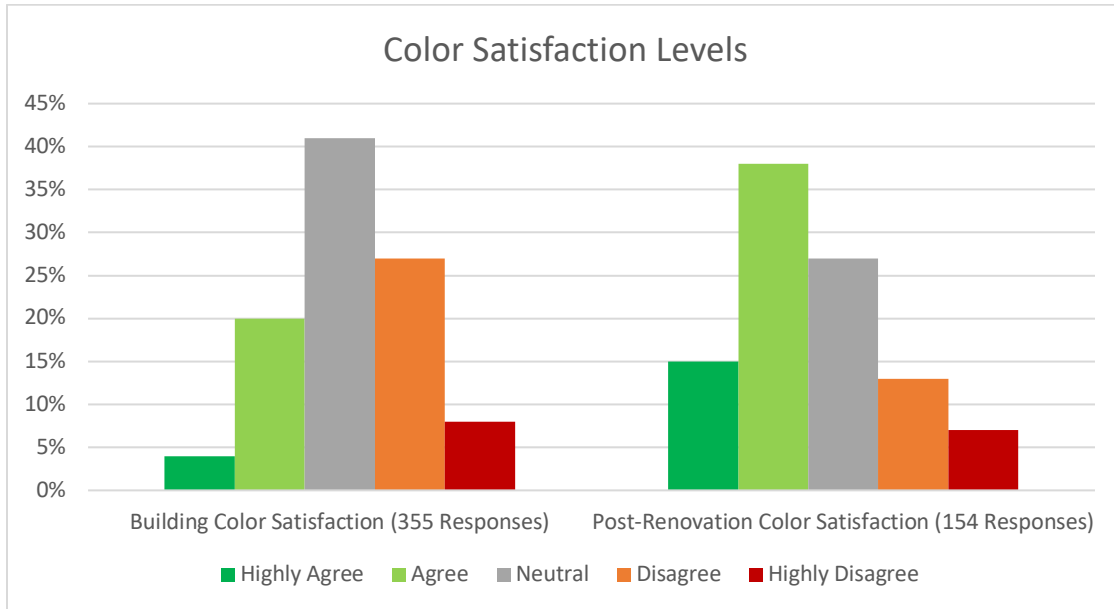


Figure 5: Color Satisfaction Levels as indicated by survey participants

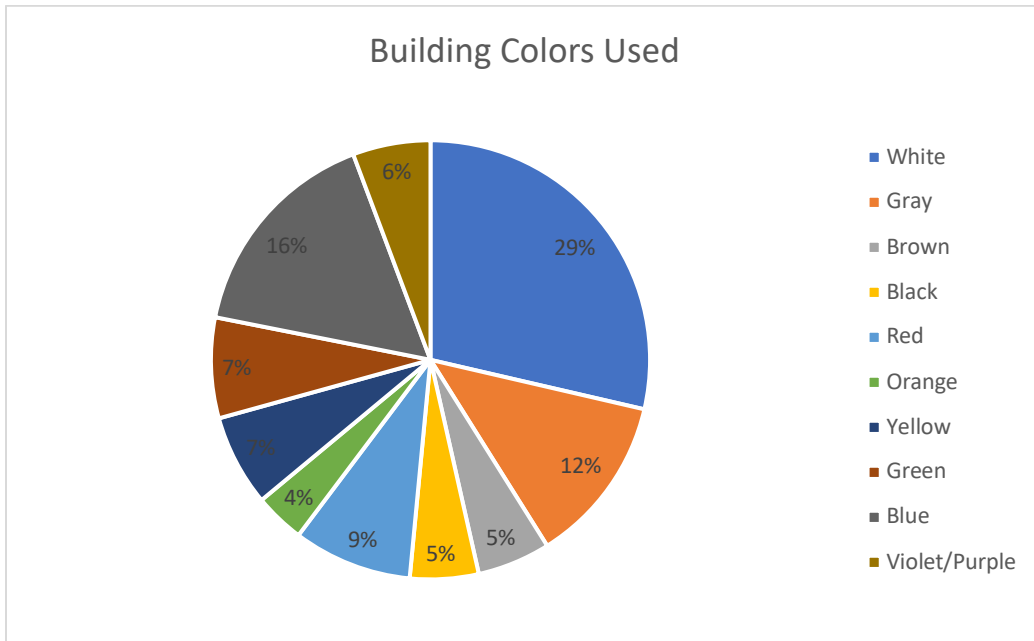


Figure 6: Color Popularity and Use within the high school of survey participants

LIGHTING

There were 406 responses to the use of lighting in their building. Roughly 67% would say the lighting did support their needs, while 17% disagreed with this. The other 15% said the lighting used neither positively nor negatively affected them. See figure 7. Over 75% of participants stated that they would prefer a warmer toned light over bright, white lighting. Only 8% disagreed with this statement. 15% responded neutrally here too. See figure 8. 156 participants responded to questions about the building during the renovation period and post-renovation. 42% stated that the construction of the renovation did not have an effect on the building's lighting. For the 33% that said there was an effect, 65% said the lighting quality did not decrease. See figure 9. When looking at post-renovation, 50% said that the lighting conditions improved, 36% had no effect, and 13% said that conditions worsened. See figure 7.

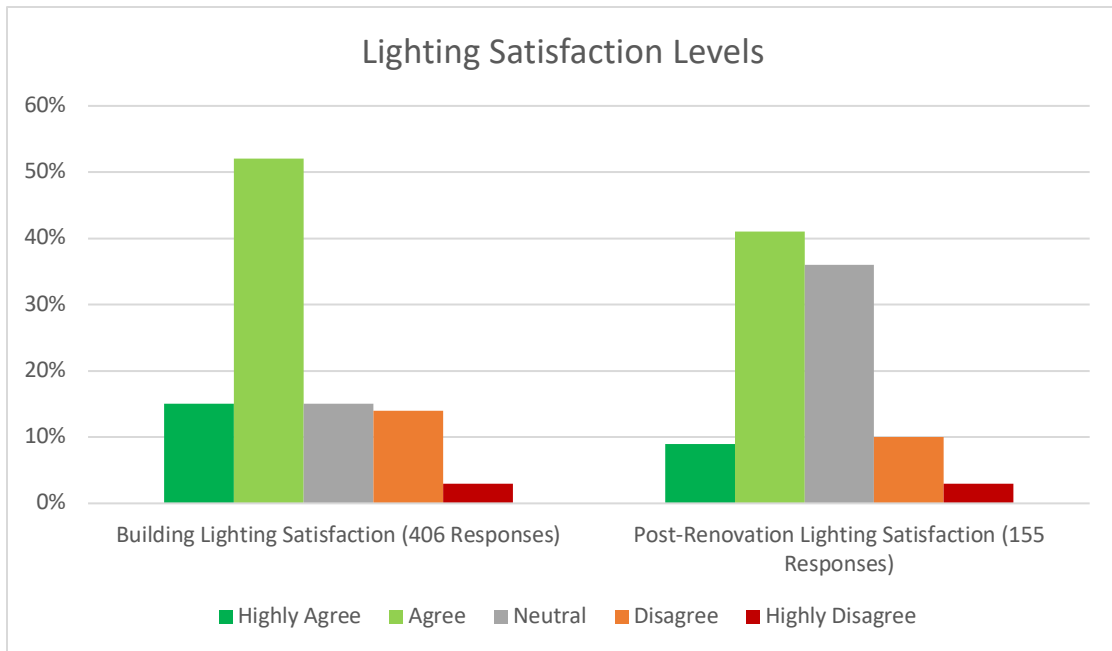


Figure 7: Lighting Satisfaction Levels as indicated by survey participants

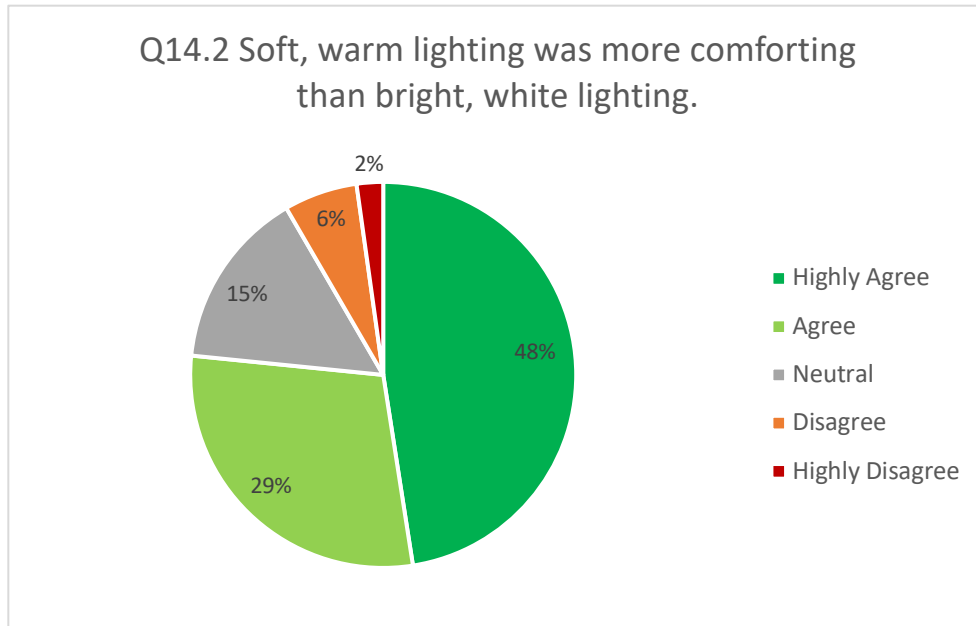


Figure 8: Lighting Color Preference as indicated by survey participants

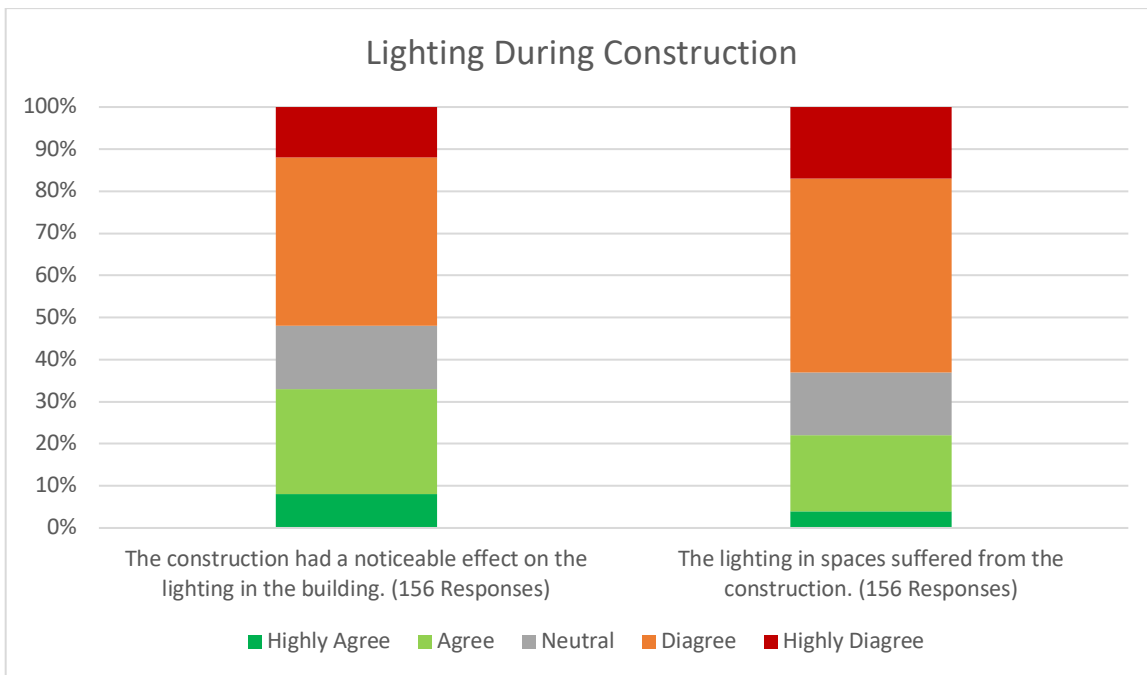


Figure 9: Lighting During Construction as indicated by survey participants

CONNECTION TO NATURE

54% of respondents stated that they did not think they had enough exterior views in their classroom. Only 39% of participants were pleased with the number of exterior views, and 7%

were neutral. See figure 10. When looking at post renovations, 41% said that the upgrades did not add to their views, while 9% remained neutral. 50% did report that the renovations added to the number of exterior views. See figure 10. Overall, only 29% said their connection to nature increased post-renovation, and 41% claimed it decreased, and 30% said it didn't increase nor decrease. See figure 11.

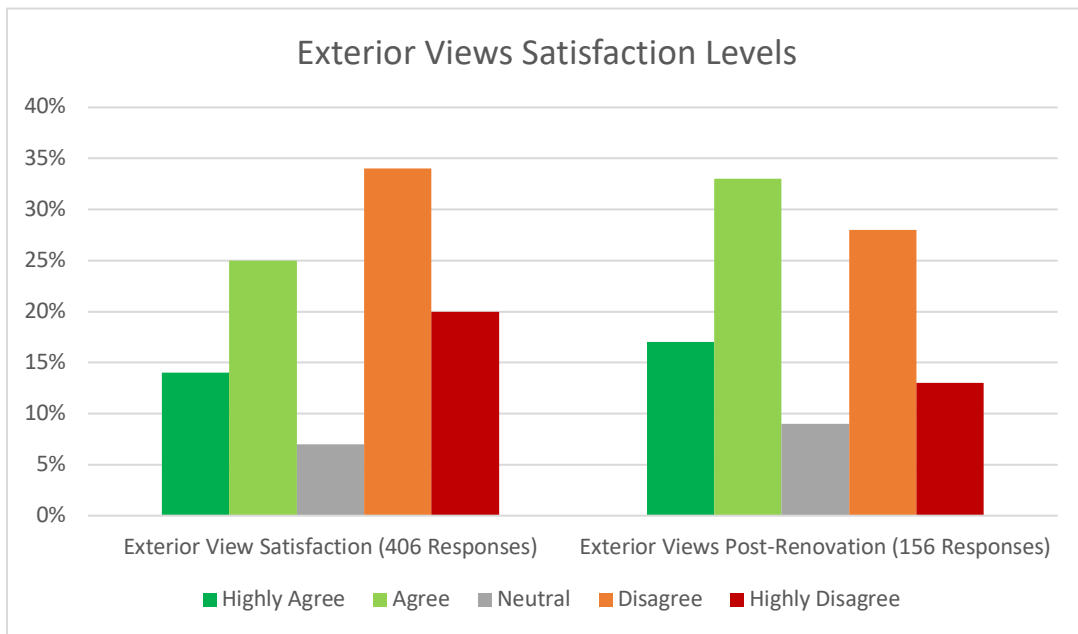


Figure 10: Exterior Views Satisfaction level of survey participants

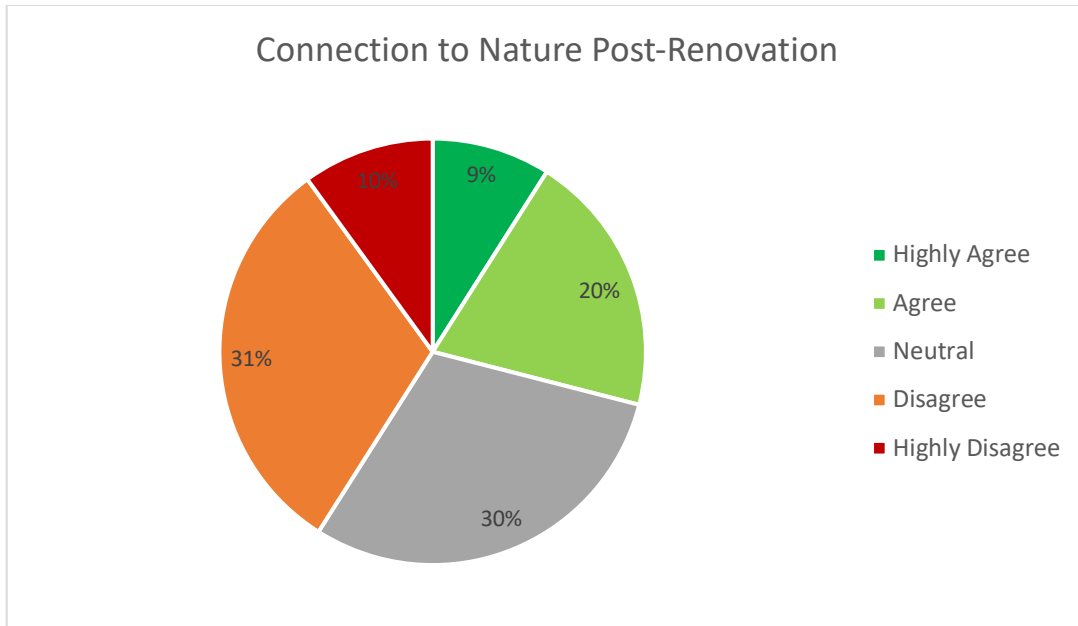


Figure 11: Connection to Nature of spaces within the high school buildings after renovation as indicated by survey participants

SENSE OF PLACE AND ERGONOMICS

50% said they did not feel like they had a place attachment to their school. 39% of responses said they did, and 11% were neutral. See figure 12. During the renovation phase, 50% of participants said the construction did not affect their place attachment. 25% of participants had a different experience and were affected, while 25% were neutral. See figure 12. Participants with post-renovation knowledge reported that 40% of participants did not see a change in place attachment and 36% said it became better than before. 24% of participants were still finding it challenging to find that sense of place. See figure 12.

Over 60% of participants stated that the furniture used was not comfortable or supported their ergonomics. 21% found the furniture was acceptable, and 17% did not have an opinion. See figure 13. Through the renovation phase, 52% said that new, more supportive furniture was introduced. 28% were neutral, and 20% reported that they disagreed with this statement. Post-renovation results showed that 50% thought that the furniture improved post-renovations. While

30% thought it was neither better nor worse, and 20% thought the conditions worsened. See figure 13.

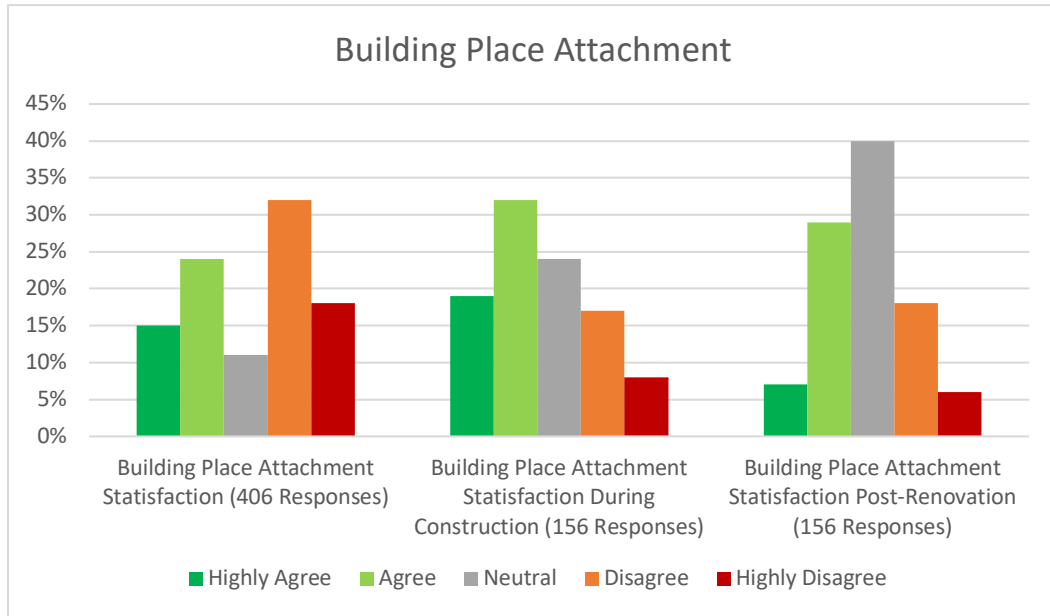


Figure 12: Building Place Attachment as indicated by survey participants

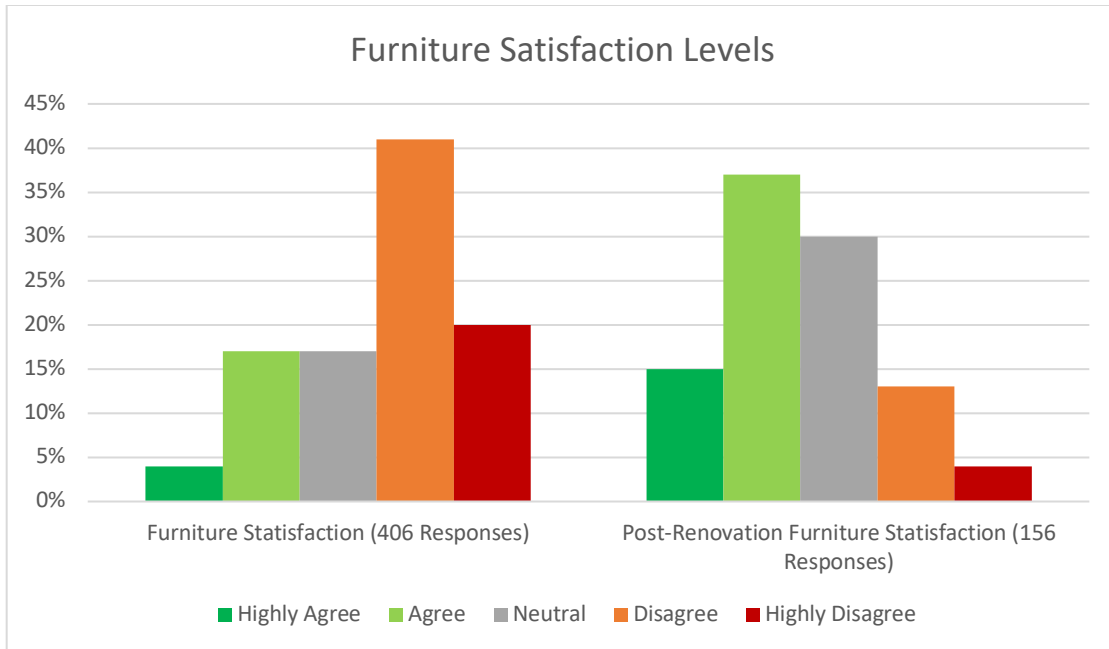


Figure 13: Furniture Satisfaction Levels as indicated by survey participants

THERMAL AND ACOUSTICAL QUALITY

46% stated that thermal quality was rarely ever an issue, while 41% disagreed with this statement. See figure 14. During the renovation period, 30% said the thermal quality increased, and 31% said that thermal quality decreased. 39% of participants were neutral here. See figure 14. Only 36% said that the thermal quality was increased post-renovation, while 47% remained neutral, and 17% thought it decreased. See figure 14.

56% of participants thought their classrooms had adequate acoustical quality. 28% did find that they had issues with outside noise and 15% were in the middle. See figure 15. 49% said acoustic quality was an issue during the renovation due to the construction. 33% did not find this to be an issue, and 17% did not have an opinion one way or another. See figure 15. In terms of post-renovation, 49% of participants stated the acoustic quality of the building improved, 35% saw no difference, and 16% said the conditions worsened. See figure 15.

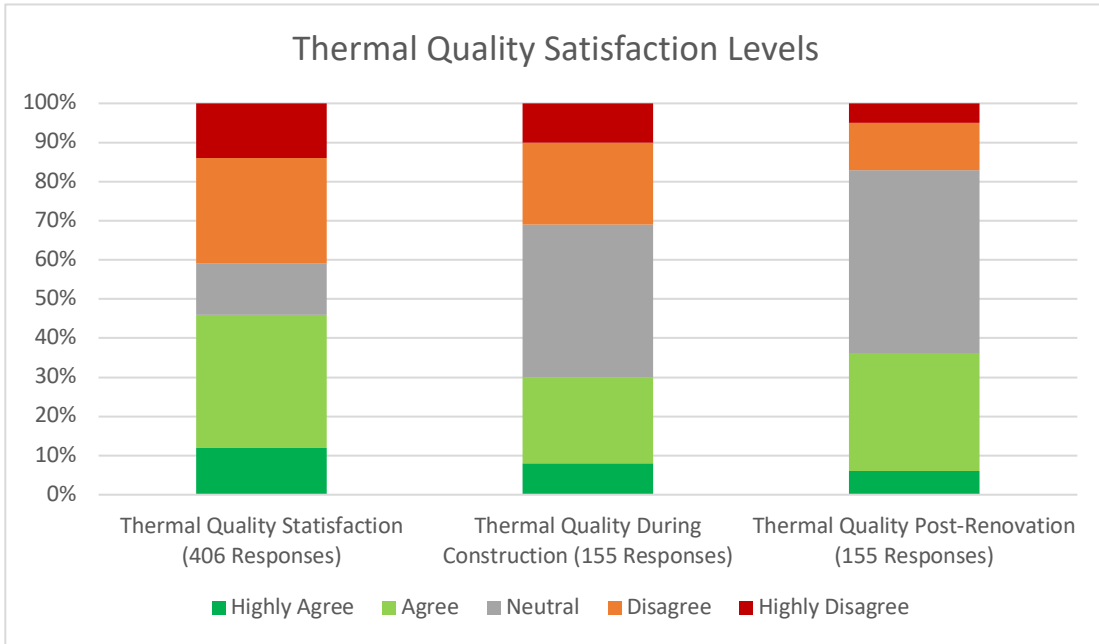


Figure 14: Thermal Quality Satisfaction Levels as indicated by survey participants

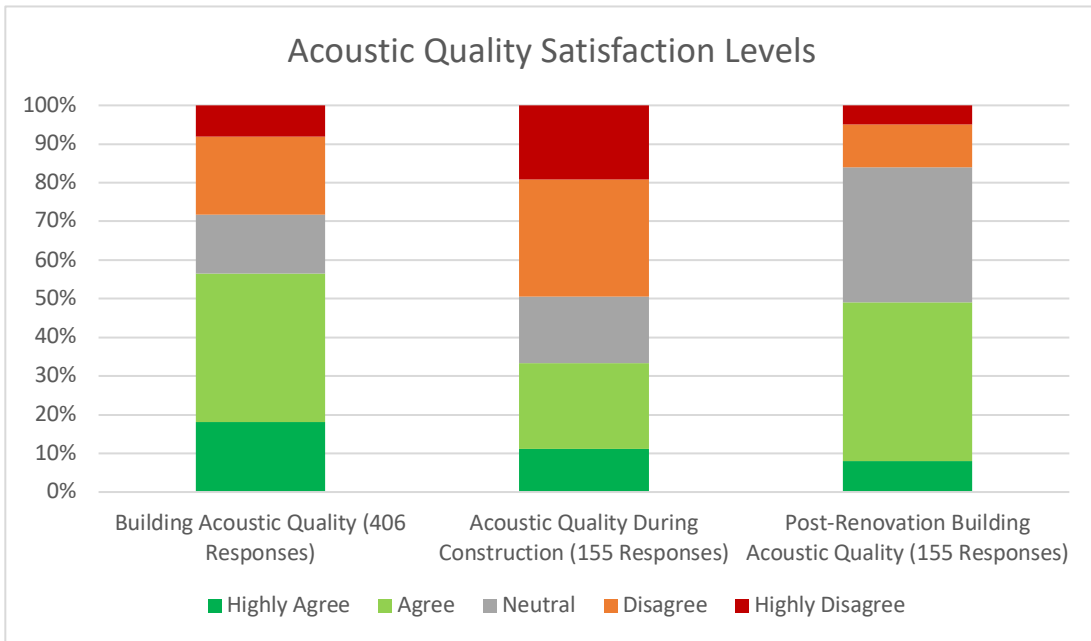


Figure 15: Acoustic Quality Satisfaction Levels as indicated by survey participants

The final question of the survey asked participants whether they preferred the building post-renovation over the initial setting. 70% of participants agreed with this statement. 19% did not have an opinion, and 11% disagreed. See figure 16.

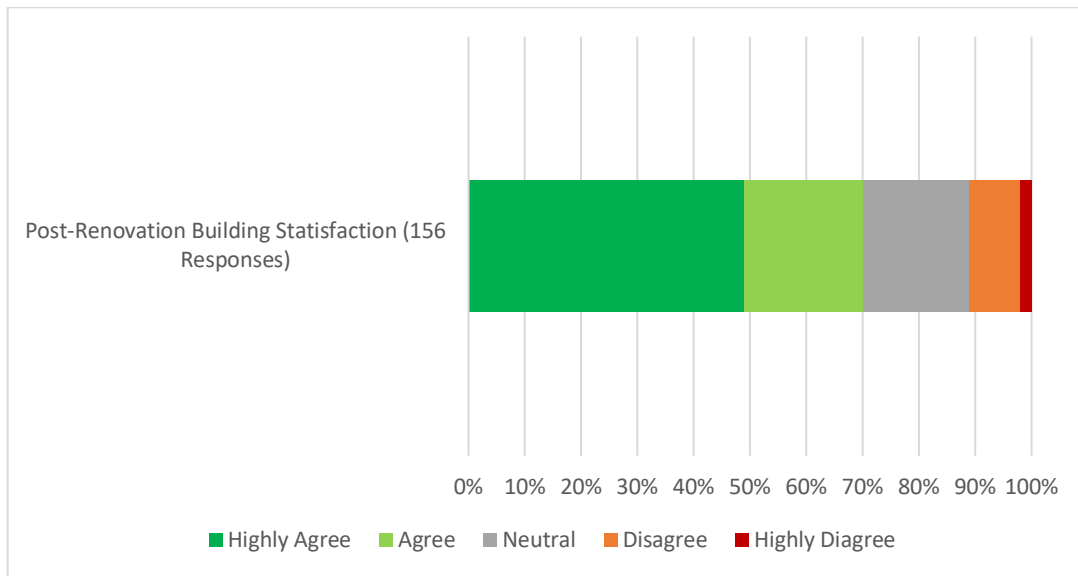


Figure 16: Post-Renovation Satisfaction as indicated by survey participants

INTERVIEW

An interview with Andrea Durbin took place on Thursday, November 4th, 2021, via Zoom Call. Durbin is an interior designer and works for MA+ Architecture. They are the firm that designed the 2017 Norman High School Renovation. Through the review of the interview, potentially important statements were transcribed. After transcribing the themes of project goals, project concerns, design strategy, lighting, indoor environmental quality, FF&E, aspects of renovation, and place attachment were found. The codes of considerations, research, solutions, pride, reasoning, and construction were then connected from the themes. See table 3 for complete interview coding.

The significant information gained from the interview is as follows. First were the areas renovated, including (1) the library, (2) the learning commons, (3) the college career center, (4) the media center, (5) the main corridor, and (6) the offices. The next piece of highlighted information was the design goals for the space. The goals were to (1) increase security, (2) create a more cohesive space, (3) create a stronger identity in the school, and (4) promote pride for the school into students. The student's mental health and biophilic design were not part of the design considerations. Parameters that were considered in the design were (1) safety, (2) collaboration, (3) acoustics, (4) color, (5) lighting, and (6) furniture. For a complete list of Durbin's answers, see table 2.

Table 3: Interview Coding

Transcribed Audio Segment	Theme	Code
"A lot of the areas in the school that we renovated were just starting to show wear and tear." (5:53)	Project Goals	Considerations
"The flooring, the wallcoverings, the walls – there were holes in the walls, the gyp. board was peeling. The paint was really dirty. The flooring was showing its age." (6:00)	Project Goals	Considerations
"Also, one of the biggest things we did was we took the media center learning commons it from the middle of the school and moved it to the outside of the school" (6:15)	Aspects of Renovation	Solutions
"So that it [the learning commons] could have daylight and join basically two building together to create a more secure environment for students so they weren't walking outside to get from one building to the next" (6:24)	Design Strategy	Reasoning
"I [Durbin] can definitely see more and more school districts starting to combine those spaces [multiple high school buildings] so that the kids aren't outside at any of the points in the day" (7:42)	Design Strategy	Solutions
"All it takes is one mentally unhealthy person to create a tragedy" (7:52)	Project Concerns	Considerations
"The best advice that we can give as architects is to try to keep the students inside or at least in a secure area even if they pass through outside" (8:00)	Design Strategy	Solutions

"During our [MA+] renovation we did the learning commons, media center, maker spaces, the main corridor, and the college and career area. And then we did the offices." (8:34)	Aspects of Renovation	Construction
"We [MA+] the freshman commons too" (9:14)	Aspects of Renovation	Construction
"It was the cafeteria that was done by another firm [someone else]" (9:16)	Aspects of Renovation	Construction
"We [MA+] just recently renovated more of the school on the most recent bond" (9:36)	Aspects of Renovation	Construction
"Really the goal is to have a new cohesive [kind of] look. The school was previously very hodge-podge." (9:40)	Project Goals	Considerations
"You go into the school, and you can tell that this is from the 1950s, and then this was done in the 70s, and this is brand new, and it's been renovated but nothing looks consistent." (9:52)	Design Concerns	Considerations
"Everything has been done by a different architect and as a new architect has come in, they haven't had any regard for what was done previously." (10:02)	Design Concerns	Considerations
"What we [MA+] tried to do was come in and create an identity for the school and make everything more cohesive." (10:15)	Project Goals	Solutions
"For Norman High School we [MA+] created material standards like this is their three floorings and colors. These are their paint colors for Norman High" (10:22)	Design Strategy	Pride
"So, we [MA+] not only on this last bond acted as an architect for the high schools' jobs we also acted as the liaison between school district and all the other architects for the bond issue" (10:34)	Design Strategy	Solutions
"I [Durbin] personally helped to establish all of the furniture standards throughout the district." (10:50)	FF&E	Solutions
"It [design process] took about nine months" (11:15)	Design Strategy	Construction
"We [MA+] do this [design] project in Revit" (11:18)	Design Strategy	Construction
"Back when all of the projects were designed in CAD most of your work was done during the construction document [CD] phase of the job. Now its more than schematic design [SD] and design development [DD] because you're actually building the model." (11:27)	Design Strategy	Solutions
"We took the district and toured some schools in Joplin [Missouri]" (11:53)	Design Strategy	Research
"We also sat down with a lot of the different focus groups in the school." (11:57)	Design Strategy	Research

"For instance, we sat down with the library group and talked about their needs and how the library is changing. It's [the library] not the place where people go and sit down and check out books anymore. The librarian doesn't just sit behind a desk; she's more interactive with the students. It's [the library] a place where people go to study; it's a place where people go to have coffee and hang out. Its [the library] is also the maker's studio." (12:03)	Design Strategy	Research
"We [MA+] had interviews with all the different client groups within the school" (12:26)	Design Strategy	Research
"We [MA+] utilized Pinterest. I [Durbin] think this is good because the clients have so many different ideas and for them to be able to pull a picture and put it on a board and say what it is they [clients] are looking at, and you can reference that. I [Durbin] think that really helped us [MA+] out" (12:32)	Design Strategy	Research
"It [Pinterest] is a really good way for those teachers and administrators to give their input and to tell you [the designer] things they like without having to sit down and get all their magazines and pictures" (13:08)	Design Strategy	Research
"I [Durbin] don't think we [MA+] necessarily said oh yes this if for the mental health of the students." (13:58)	Project Concerns	Considerations
"One of our [MA+] designers here has her WELL AP and we [MA+] taught just to consider those things [like] how are the students going to interact in a space?" (14:08)	Design Concerns	Considerations
"We [MA+] wanted the students to feel at home as possible during the renovation, so how are we [MA+] going to keep them [the students] out of the construction zone and make them [the students] feel like they're still having a regular school year even though their world is chaos." (14:19)	Project Concerns	Considerations
"I [Durbin] don't necessarily think that we [MA+] sat down and said okay what is the mental health of the students, but I [Durbin] do think it was considered in a lot of different aspects during the construction period." (14:33)	Project Concerns	Considerations
"The construction took about 14 months." (14:50)	Aspects of Renovation	Construction
"Construction began in January" (15:19)	Aspects of Renovation	Construction
"That gave us [MA+] the Christmas break to be able to stage that construction site and redirect the students around the construction." (15:24)	Design Strategy	Solutions

"I [Durbin] do know that Norman Public Schools was really happy with the way that we [MA+] were able to keep the school going and continue construction during that time [school year]." (15:40)	Aspects of Renovation	Construction
"It is really important for us [MA+] as ordinary of a year as possible for the kids. So, monitoring when big, loud, heavy machinery is going on, restricting the times of day when that could happen so that it's [the construction] is not being disruptive to class" (15:54)	Project Concerns	Solutions
"Of course, it is not a perfect situation, and there is always going to be some distraction." (16:13)	Design Concerns	Considerations
"For the 2014 bond and the way we [MA+] handled it [the bond] is what got us [MA+] on the bond coordinators for 2019 bonds that we [MA+] did" (16:22)	Aspects of Renovation	Construction
"I [Durbin] don't think that it [the construction] was a huge impact. I [Durbin] think for the most part most of the kids just went about their days as normal as possible." (16:50)	Aspects of Renovation	Construction
"Of course, there are some things that are not ideal during construction, but I [Durbin] think it would be interesting to hear from some of the students that were there during the time [of construction] to see if they [the students] felt jaded or neglected." (17:02)	Aspects of Renovation	Research
"But I [Durbin] would honestly say that I [Durbin] felt like we [MA+] did a really good job of keeping the school going and working with Norman Public Schools to do that." (17:24)	Aspects of Renovation	Solutions
"As far as lighting types, everything that was in the school previously was old light fixtures" (17:48)	Lighting	Solutions
"Everything [lighting types] was switched to LED" (17:55)	Lighting	Solutions
"One of the things that was really important is that the maintenance crew be able to maintain the fixtures. So we [MA+] wanted to make sure we [MA+] weren't using 200 different types of fixtures in the space." (17:57)	Design Concerns	Solutions
"We [MA+] have used linear fixtures as an accent in several different places. Some of them [light fixtures] are pedants that are encased in their own housing, and then some of them [light fixtures] are recessed in the wall, but they're actually the same fixture; they just have a different type of housing. That makes it easy for the maintenance to know how to handle them [light fixtures] because it's the same fixture." (18:16)	Lighting	Reasoning
"We [MA+] also utilized the same fixtures in Norman North." (18:42)	Lighting	Solutions

"Now in most of the areas we [MA+] just stuck with a 2'x2' architectural looking fixture that fits into the acoustic ceiling for the most part." (18:45)	Lighting	Solutions
"It's really important to use the money where you [the designer] are going to get the most bang for your buck so the most public areas would be places where we [MA+] would use those accent fixtures." (18:57)	Design Concerns	Reasoning
"They're [the 2'x2' light fixtures] going to be more of indirect lighting." (19:19)	Lighting	Solutions
"We [MA+] used orange because that's their [Norman] school color." (19:42)	Place Attachment	Pride
"We [MA+] really wanted to evoke school pride. We [MA+] wanted the students to be proud of their space so they [the students] would take care of it. A lot of the stuff we [MA+] covered up or replaced or renovated had gratify, and students had taken pens and markers to things." (19:47)	Place Attachment	Pride
"We [MA+] just wanted them [the students] to be proud of their new space so that they would maybe take care of it. That was a goal to just give them [the students] school pride and make everything more cohesive." (20:07)	Place Attachment	Pride
"I [Durbin] can't really think of anything in particular that we [MA+] use that was a biophilic design for the space." (20:30)	Design Concerns	Considerations
"We [Norman High School] do have a lot of windows in that learning commons, but we [MA+] didn't really use the biophilia design." (20:37)	Lighting	Solutions, Considerations
"We [MA+] took that space that was their [Norman High School] learning commons or library, and it was in a very enclosed, dark, cave-like space, and we [MA+] moved it [the learning commons and library] to the exterior of the building where they [the learning commons and library] could have lighting and a lot of natural light." (21:01)	Design Strategy	Solutions
"Like I [Durbin] said, we switched all the lighting to LED lights; the learning commons itself does have daylight harvesting, which means that the lights actually dim based on the sunlight. In the middle of the space [learning commons] where there's not a lot of sunlight, the light fixtures might actually be brighter than the ones [light fixtures] on the outside, but you [an occupant] really can't tell." (21:15)	Indoor Environmental Quality	Solutions

<p>"In changing people's perspective from the library being that quiet, study space to being this more of a hub of the school, we [MA+] knew there were going to be some areas that needed to be more quiet. So, we [MA+] do have some concentrated areas in the library that are more acoustical sound with a lower ceiling with acoustic tiles, carpet instead of an LVT, and some acoustic panels to make sure that those areas remain a little bit more focused." (21:51)</p>	<p>Indoor Environmental Quality</p>	<p>Solutions, Considerations</p>
<p>"Whereas the area where the coffee bar is definitely a little more aloud and live." (22:23)</p>	<p>Indoor Environmental Quality</p>	<p>Considerations</p>
<p>"The idea of the school pride and the use of the school fight song and mission statement was incorporated into a lot of the focal points around the entry of the school." (22:41)</p>	<p>Place Attachment</p>	<p>Pride</p>
<p>"We [MA+] also had this huge tiger paw in the ceiling of the library that was behind some acrylic panels, and it's [the tiger paw] glows." (22:55)</p>	<p>Place Attachment</p>	<p>Pride</p>
<p>"The school logo was also incorporated throughout the space like anytime there was a conference space with glass walls, we [MA+] had the logo across the glass walls." (23:08)</p>	<p>Place Attachment</p>	<p>Pride</p>
<p>"The furniture for this project [Norman High School] was actually done by one of our [MA+] designers that now works for Johns Hopkins Children's Hospital." (23:37)</p>	<p>FF&E</p>	<p>Solutions</p>
<p>"This [furniture selection] was the first big furniture project that MA+ did for Norman Public Schools, and what we [MA+] was able to do was really see what the problems were with the existing furniture and get new products that were more sustainable." (23:47)</p>	<p>FF&E</p>	<p>Solutions</p>
<p>"For instance, most libraries have wooden bookshelves that are really heavy and hard to move that don't hold up very well. They [wooden bookshelves] get dings and banged, and the wood warps and bends. We [MA+] switched them to metal products with laminate tops that are mobile, and they [the occupants] can move them around as they [the occupants] need to." (24:05)</p>	<p>FF&E</p>	<p>Considerations</p>
<p>"We [MA+] specified some chairs that had wooden caps on the arms, and the students craved into the wooden caps. So this time around, when I [Durbin] created their [Norman Public Schools] standards, I [Durbin] knew that [wooden caps] were a bad idea. We [MA+] have not used anything with wood cap arms or anything like that moving forward." (24:24)</p>	<p>Design Concerns</p>	<p>Considerations</p>

"So there have been changes that we [MA+] have learned from that project [Norman High School]" (24:52)	Aspects of Renovation	Considerations
"Like I [Durbin] said one of the biggest goals was just to try to create that pride with the students and so maybe they [the students] would take better care of their stuff." (25:25)	Project Goals	Pride
"When you [the user] have an old, nasty building, it's easy to be like 'oh I made a mark in the wall, who cares?' But with the new, pretty building, hopefully, that is not something that doesn't happen" (25:32)	Place Attachment	Pride
"We [MA+] also changed all the fabrics that were being used; Noman wanted to go from woven fabrics to non-woven. Everything we [MA+] use now is polyurethane or silica. So that they [the maintenance] can wipe it [the fabric] off." (25:51)	FF&E	Solutions
"I [Durbin] think that the learning commons or the library was the biggest improvements. Just because it [the spaces] went from an area that the kids did use at all except as a pass-through to being really the hub of the school." (26:17)	Aspects of Renovation	Solutions
"If you [an occupant] were to go to Norman High School now and walk into their learning commons, it is full all of the time. There are kids having coffee. There are kids at the IT help counter. There are kids in the maker studio. It's [the learning commons] the heart of the school now. Which is really what the intention was." (26:30)	Aspects of Renovation	Solutions
"We've [MA+] also seen a lot of libraries start to have off-site storage. So, the actual books will maybe be in an off-site warehouse, and you [the user] would check them [the books] out a day before you [the user] needs them, and then they'll [the library] send a library aid to the warehouse to find them [the books] and bring them [the books] back to the library. More of the space in the actual library is open and collaborative and less storage for books." (27:06)	Design Strategy	Reasoning
"A lot of kids will actually buy their books on a Kindle, and they [the kids] don't even want to have a physical book. Why devote 80% of the space, the SQFT, which is very valuable to books that nobody's ever going to check out?" (28:07)	Design Strategy	Reasoning

<p>"This is something [underdeveloped spaces] that we [MA+] have been able to address in this bond that we're [MA+] currently finishing. We [MA+] were able to make these areas [2017 Bond] that we [MA+] did so fantastic, we [MA+] were able to create that school spirit, but then it made the other areas school really sad. That is something we [MA+] been able to do is go back and add the design to the rest of the school cohesive." (28:42)</p>	<p>Design Strategy</p>	<p>Solutions</p>
<p>"Renovations are one of the biggest challenges, and I [Durbin] feel like one thing that our firm [MA+] does really well is going in and making a space look like a whole new space and without just sticking a Band-Aid on it." (29:56)</p>	<p>Aspects of Renovation</p>	<p>Considerations</p>
<p>"You [the designer] have to be careful with renovations because you [the designer] are going to have a bunch of things that you [the designer] don't know are problems until they actually start the demolition." (30:12)</p>	<p>Aspects of Renovation</p>	<p>Considerations</p>
<p>"It [renovation design] is all about how you [the designer] solve those problems and how do you [the designer] make them a solution that is going to last a long time." (30:23)</p>	<p>Design Concerns</p>	<p>Considerations</p>
<p>"If our [MA+] client is going to put money into something, I [Durbin] want to make sure that it [the design] is done correctly and it [the design] is going to last." (30:49)</p>	<p>Design Concerns</p>	<p>Considerations</p>
<p>"With any renovation project that's probably one of the biggest challenges is trying to figure out how you're [the designer] going to make whatever you [the designer] do to brighten up the space, or make the space look nicer, how you [the designer] are going to make that last more of the lifetime of the space." (30:56)</p>	<p>Design Concerns</p>	<p>Considerations</p>

CONCLUSION

The results helped to create a picture of what indoor parameters are being considered during high school renovations. It also gave a broad sense of building satisfaction levels amongst high school graduates. The survey results showed students’ design preferences from colors to furniture used. The results from the survey showed where current indoor environmental parameters are effective and where they could be improved. The interview gave the author a look

into what the design intentions were. This helps when looking at why particular design decisions, like the selected color scheme, were made. The data gathered here adds to the information obtained through the literature review. Which in terms works to answer the research questions listed in Chapter 1.

CHAPTER V: DISCUSSION & CONCLUSION

INTRODUCTION

This chapter of the study concludes the significant findings from the literature review and survey/interview and answers the research questions. It then gives the unexpected discoveries that have come from the research. This information is then taken, and design recommendations for the identified case study are presented. The chapter then talks about the need for further research and action to be taken.

INDOOR ENVIRONMENTAL PARAMETERS

COLOR

1. How can color affect a person's psychology?
2. Are there specific colors that are more beneficial to a person's mental health than others?
3. How can the application of color in education affect the mental health of students?

Major findings in literature

The color-chakra theory is a practice that begins with the Hindu faith (O'Connor, 2011). The color-chakra theory looks at how colors are used to increase a person's bodily functions. O'Connor (2011) studied the connection between a charka and its assigned color. The effects are both physical and mental. Blue is said to be healing, while green aids in decreasing stress (O'Connor, 2011).

In a study by Elliot and Maier (2014) examined in the literature review, it was found that colors affect the psychological functioning of humans. For example, Elliot and Maier (2014) found that sports teams with red color schemes have the highest performance rates. Their study concluded that red doesn't necessarily increase the group's performance using the color but the

opponents (Elliot & Maier, 2014). Elliot and Maier (2014) found that red causes opponents to see the competitors in red as dominant, assertive, and intimidating. As a result, this makes the red team's competitors not as aggressive (Elliot & Maier, 2014). When Elliot and Maier (2014) looked at individual performance, the results for red were the opposite. Red was typically connected to failure and overstimulation (Elliot & Maier, 2014).

Similarly, Dukes and Albanesi (2013) found that when students' assignments were marked up in red, the students immediately perceived the feedback as unfavorable. When the markups were given in blue, students saw the comments as constructive and interpreted the messages better (Dukes & Albanesi, 2013).

Yu (2014) studied the various symbolism and meaning of colors across the world and cultures. He found that with every color, there is a positive and negative meaning behind it. For example, blue can mean truth, stability, or peace. But blue can also stand for depression, loneliness, and isolation (Yu, 2014). Because of these findings, Yu (2014) stresses the importance of designers understanding the meanings of color and appropriately selecting colors with their cultural significance (Yu, 2014).

When looking at the application of color in the built environment, Uluçay (2019) questioned students, ages 18 – 30, over their classroom color preference. The result collectively showed their preference for the yellow and blue classrooms. The participants preferred the colors to be softer and liked the complementary color scheme the best (Uluçay, 2019). In another study by Costa et al. (2018) analyzed occupant response in residential halls. It was found that the students in the hall with blue interiors had the best productivity rates and most relaxing moods. In comparison, the red/orange interiors had the lowest productivity rates, with occupants piercing the space as harsh (Costa et al., 2018).

Major findings in survey/interview

The surveyed results showed that 58% of participants found that the colors used in their high school building did influence their performance. 23% agreed that the color had positive influences. 35% disagreed with that statement and thought the colors negatively impacted them. Because the percentage of occupants that reported back that the color negatively affected them points to believing that occupants will notice when the color does not support them over noticing that the color does.

The participants who said they felt like the school's colors positively supported them were prompted to list the colors used. The most popular background color was white, being used in 29% of the color schemes. The most popular primary color was blue at 16%. Red was 9%, green was 7%, yellow was 7%, purple was 6%, and orange was 4%. The post-renovation results showed that 53% of participants felt like the updated colors improved the space and performance.

How does it answer research questions?

Taking the information found in the literature with the results from the survey show that colors can have a psychological impact on occupants through the perception of color and the meanings/symbolism of colors. The color that is the most beneficial to the mental health of occupants would be blue. It was found to be the favorite interior color in three different studies. When a color's characteristics are entirely taken into consideration and applied in an educational setting, the effects will support the student's functioning lessening the mental stress they can experience.

LIGHTING

1. What happens to a person when they have prolonged exposure to poor lighting?

2. What role does daylighting play in a student's performance?
3. How can lighting be used to offset the causes of mental health problems?

Major findings in literature

Katabaro and Yan (2019) explained that poor lighting could lead to visual discomfort. The effects of visual discomfort often cause occupants to experience anxiety, the inability to concentrate, irritability, or mental/physical fatigue (Katabaro & Yan, 2019). The research showed that when a uniform, high-level light was given, occupants in a workplace increased their concentration and productivity, increasing the occupant's mood (Katabaro & Yan, 2019). Salonen et al. (2013) found that when occupants do not have access to lighting controls, stress and discomfort increase; when occupants do have control, satisfaction, mood, and motivation increase (Salonen et al., 2013).

Daylighting directly influences the human's circadian rhythm, which affects their mental health (Mirrahimi et al., 2013). To keep a person's circadian rhythm aligned, it is imperative that the person has access to natural light for a minimum of three hours a day (Mirrahimi et al., 2013). Mirrahimi et al. (2013) discovered in their study that student performance in a setting with natural light is 20% higher than students with no natural light.

Bright Light Therapy (BLT) is a current therapy method for treating Seasonal Affective Disorder (Campbell et al., 2017). Kukhta et al. (2018) looked at taking BLT and applying it through interior lighting. Instead of a person taking time out of their day for BLT, they hypothesize that it could be given slowly over the course of the day to occupants. The results were promising, but in order to confirm that it works, there needs to be more medical review (Kukhta et al., 2018).

Major findings in survey/interview

When asked whether the building's lighting supported the student's performance, 67% of participants did say the lighting was adequate. 17% disagreed with this and said there wasn't enough light. Though post-renovation results showed that 50% of participants saw an improvement in the lighting used. 75% of participants reported that they preferred a warmer toned light over a bright white light.

How does it answer research questions?

The results from Kataro and Yan (2019) and Salonen et al. (2013) show that poor lighting leads to both physical and mental health issues. The support of an occupant's circadian rhythm is vital to a person's mental health (Mirrahimi et al., 2013). Providing occupants with appropriate lighting levels, a bright, warm-colored lamp type, and giving occupants adjustment controls will help create an environment that promotes occupant well-being in both mental and physical capacities. Mirrahimi et al. (2013) showed that natural light is vital to a student's performance and that the student's performance is directly affected when daylighting is taken out of the equation.

BIOPHILIC DESIGN

1. Why do humans crave a connection to nature?
2. What are the benefits that nature can bring a person?
3. How can biophilic principles be incorporated into classroom settings?

Major findings in literature

Kellert and Calabrese (2015) talk about the human connection to nature being an instinctual need. They talk about how it is relatively recent that humans have been living in this manufactured world. The human mind, body, and perception are bio-centric and respond in that

manner (Kellert & Calabrese, 2015). Biophilic design is a theory that brings the connection of nature to the built environment (Ryan & Browning, 2020).

In a study by Kellert et al. (2011) it was found that children in a biophilic community have easier times developing and experiencing more positive emotions. Biophilic design increases productivity, concentration, healing, and memory. It also decreases stress and social issues (Kellert et al., 2011). Brubaker (2020) concluded that biophilic design leads occupants to experience higher levels of self-esteem and a sense of belonging, which both support more substantial mental health (Brubaker, 2020). Peters and Penna (2020) looked at how universities incorporate biophilic design into campuses. The most common method was through visual implementation. These can be seen as the use of natural colors, indoor plants, and exterior views (Peters & Penna, 2020).

Kellert and Calabrese (2015) explain how the principles of biophilic design are incorporated into a space. Occupants experience the connection to nature in one of three ways: (1) directly, (2) indirectly, and (3) space/place. The principles make sure these experiences are included in the design (Kellert & Calabrese, 2015).

Major findings in survey/interview

The survey results from the connection to nature section showed that 54% of participants did not think there was a strong enough connection to nature. 50% of participants said their access to exterior views increased through the renovation, but only 29% of students claim their connection to nature increased.

How does it answer research questions?

Kellert and Calabrese (2015) explain the need for connection to nature as a human instinct. That humans are programmed to be in sync with nature (Kellert & Calabrese, 2015).

The benefit that's the connection to nature brings persons are numerous. There is increased productivity and mood. Social issues and stress also decrease (Kellert et al., 2011). It also leads to a sense of belonging and higher self-esteem. Both of these factors positively influence mental health (Brubaker, 2020).

The survey results show that the application of biophilic design needs to include more than just exterior views. Even exterior views were increased; only 29% of students said the connection was strengthened—the application of all five biophilic design principles is needed to ensure total connection. Biophilic design can be emulated in a classroom through direct/indirect experiences and the experience of space/place (Kellert & Calabrese, 2015).

UNEXPECTED FINDINGS

There were a few surprising findings through this study. The first was red, being the second most popular used color in the survey. From the information collected in the literature review, it seemed red would have been lower. Another unexpected result was the student's preference for warm-colored artificial lighting. Again, from the literature review, spaces with warmer colored lights had a lower productivity rate and did not stimulate the occupants. The last piece of shocking information was in the interview when the designer said they had not directly thought about the mental well-being of the students.

DESIGN RECOMMENDATIONS FOR CASE STUDY

Figures 17, 18, and 19 were pulled from MA+ Architecture's website. The three images contain the college career center in the library, the main corridor, and a flex-use meeting room. Starting with the color used. The primary color in this scheme is orange. The literature and survey showed that orange is one the least liked colors among users and the least productive colors in a learning setting. Keeping the orange is essential, and it can remain by switching to a

spilt-complementary color scheme. This way, the building can still show its pride in the school color and bring in blue and green to the space. Connection to nature is something that some occupants still found to be missing. Increasing the use of green would help students with this connection. Also, they could incorporate more indoor plants into the interiors.

The school could also introduce more daylighting into the space. The designer had moved the career center and learning commons to the exterior to increase the daylighting, but the task-producing areas are not placed there; instead, the social areas are. Flipping the two areas could increase the use of biophilic design and increase students' connection to nature. Taking more advantage would also aid the lighting in the space. From the research, it was found that students' performance increases with daylighting. The current lighting in the study areas is a basic overhead troffer, with a direct, bright, white color. Switching these to be an indirect, warmer tone light might be more accepted by the students.



Figure 17: Norman High School College Career Center



Figure 18: Norman High School Technology Bar



Figure 19: Norman High School Library Classroom

RECOMMENDATIONS FOR FUTURE STUDIES

Through this study, many new questions have been brought to the surface. The first one would be to look more into the role that place attachment plays in mental health. Place attachment and territorial are both topics that are highly studied, but their regard to mental health and occupant well-being is relatively small. Another area would be to focus more on student performance how that relates to a student's mental health. This study touched briefly on how

student performance will factor into whether a child completes their high school education. Researchers need to investigate whether the scores of the performance matter or is it the output of work that influences mental health. With increasing rates of mental health disorders, designers must change the way they look at educational design.

CONCLUSION

This study looked to uncover the influences of the built environment on mental health and some of the indoor environmental parameters that help shape a student's well-being. The research found that designers can alter occupant response and well-being using color, lighting, and biophilic design principles. If interior designers and architects can start to implement these findings into the built environment, then students will be given a supportive educational environment. Designers must understand that their design decisions can leave lasting impressions on their occupants in both a positive and negative manner.

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APENDIX A: IRB CONSENT FORM

Informed Consent

You are invited to participate in research about the built environment pertaining to the well-being of occupants in high school settings.

If you agree to participate, you will complete this approximately 5-10 minute online survey.

There are no risks or benefits.

Your participation is voluntary and your responses will be confidential.

There is no compensation for your participation and responses.

We will not share your data or use it in future research projects.

Even if you choose to participate now, you may stop participating at any time and for any reason.

Data are collected via an online platform not hosted by OU that has its own privacy and security policies for keeping your information confidential. No assurance can be made as to their use of the data you provide.

If you have questions about this research, please contact:

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You can also contact the University of Oklahoma – Norman Campus Institutional Review Board at 405-325-8110 or irb@ou.edu with questions, concerns or complaints about your rights as a research participant, or if you don't want to talk to the researcher.

Please print this document for your records. By providing information to the researcher(s), I am agreeing to participate in this research.

APENDIX B: BUILDING SURVEY

Q3 Do you want to consent to the survey?

- Yes (1)
- No (If no- cannot participate) (2)

Skip To: End of Survey If Do you want to consent to the survey? = No (If no- cannot participate)

Q1 Are you 18 years of age or older?

- Yes (1)
- No (If no- cannot participate) (2)

Skip To: End of Survey If Are you 18 years of age or older? = No (If no- cannot participate)

Q4 Demographics

Q5 Age

- 18-24 years (1)
 - 25-30 years (2)
 - 31-39 years (3)
 - 40-49 years (4)
 - 50+ years (5)
-

Q6 Which of the following best describes you?

- Asian or Pacific Islander (1)
 - e (2)
 - Hispanic or Latino (3)
 - Native American or Alaskan Native (4)
 - White or Caucasian (5)
 - Multiracial or Biracial (6)
 - A race/ethnicity not listed here (7)
-

Q7 Type of High School Education

- Public High School (1)
- Private High School (2)
- Homeschool (3)
- GED (4)
- Other (5)

Skip To: End of Survey If Type of High School Education = Homeschool

Skip To: End of Survey If Type of High School Education = GED

Skip To: End of Survey If Type of High School Education = Other

Q8 Year of Graduation

Q9 State of High School

▼ Alabama (1) ... Wyoming (53)

Q12 Building Analysis

Q14 Evaluate the interior of your high school in terms of occupant well-being. Rate your level of agreement with the statements below.

	Highly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Highly Agree (5)
Did you find that the overall lighting in the space supported your needs? (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Soft, warm lighting was more comforting than bright, white lighting. (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The colors in the building supported my performance. If so, what were some of the colors used? (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There was an adequate number of outdoor views from classrooms. (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Did you feel like you have a place to call your own in the building? (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The furniture used in the classroom was comfortable and supported ergonomics. (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The thermal quality (A/C, heating, etc.) was effective and rarely was an issue. (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Outside noise and sounds did not affect the experience you had in a classroom. (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Page Break

Q13 Did you attend Norman High School?

- Yes (1)
- No (2)

Skip To: Q15 If Did you attend Norman High School? = Yes

Skip To: Q19 If Did you attend Norman High School? = No

Page Break

Q15 Did you attend Norman High School during the 2015 - 2017 renovation?

- Yes (1)
- No (2)

Skip To: Q16 If Did you attend Norman High School during the 2015 - 2017 renovation? = Yes

Skip To: Q20 If Did you attend Norman High School during the 2015 - 2017 renovation? = No

Page Break

Q19 Did you attend a high school that went through a renovation period?

- Yes (1)
- No (2)

Skip To: Q16 If Did you attend a high school that went through a renovation period? = Yes

Skip To: Q17 If Did you attend a high school that went through a renovation period? = No

Page Break

Q16 Evaluate the interior of your high school in terms of occupant well-being during renovation period. Rate your level of agreement with the statements below.

	Highly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Highly Agree (5)
The construction from the renovations caused major changes in day-to-day functioning. (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The construction had a noticeable effect on the lighting in the building. (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The lighting in spaces suffered from the construction. (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
With the renovations, more color was introduced into the building. (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The renovations increased the number of outdoor views. (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The construction affected your place attachment in a negative manner. (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The new furniture introduced was more supportive than previous furniture pieces. (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The thermal quality (A/C, heating, etc.) was increased. (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The noises from construction distracting during instruction. (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q18 Evaluate the interior of your high school in terms of occupant well-being post renovation period. Rate the design parameters below based on if they created a better environment post renovation than pre renovation.

	Highly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Highly Agree (5)
Lighting (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Color (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Connection to Nature (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sense of Place (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Furniture (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Thermal Quality (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Acoustical Quality (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Overall, the post-renovations created a better environment over pre-renovations. (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Page Break

Display This Question:

If Did you attend Norman High School? = No

Q17 Will you be willing to share the name of your high school?

Yes (4)

No (5)

Skip To: End of Survey If Will you be willing to share the name of your high school? = No

Display This Question:

If Did you attend Norman High School? = No

And Will you be willing to share the name of your high school? = Yes

Q24 Please list school name here.

Q20 Can we contact you in the future for further questions?

Yes (1)

No (2)

Skip To: Q21 If Can we contact you in the future for further questions? = Yes

Skip To: End of Survey If Can we contact you in the future for further questions? = No

Q21 Please provide your preferred email address.

End of Block: Default Question Block

APENDIX C: INTERVIEW QUESTIONS

- 1) What were the main goals for the renovation at Norman High School?
- 2) Which areas of the school were renovated? Was anything kept the same?
- 3) How long did the design process take?
- 4) What types of information gathering did you use for design research? Articles, interview, observation, etc.
- 5) Was the mental health of the students a consideration while designing the renovation?
- 6) How long did the construction portion take?
- 7) Do you think the construction had an effect on the students?
- 8) What types of lighting was selected for the classroom, hallways, and cafeteria?
- 9) What color scheme was chosen?
- 10) Was biophilic design incorporated into the building? If so, how?
- 11) What were some of the IEQ measures taken?
- 12) Were there any acoustical considerations made?
- 13) Was the place-attachment theory incorporated?
- 14) What changes were made the furniture used?
- 15) Which areas do you find improved the most through the renovation?
- 16) Are there any areas of the design that could have been developed further?
- 17) Is there anything you would like to share about the project that you haven't mentioned yet?
- 18) Are there any available sketches, research, construction drawings, etc. concerning the renovation that could be shared with me for the use of a case study?