

DAYLIGHTING AND OCCUPANT DENSITY: AN INDOOR ENVIRONMENTAL
QUALITY ANALYSIS OF APPALACHIAN STATE UNIVERSITY CLASSROOMS

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by
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Abstract

DAYLIGHTING AND OCCUPANT DENSITY: AN INDOOR ENVIRONMENTAL QUALITY ANALYSIS OF APPALACHIAN STATE UNIVERSITY CLASSROOMS

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This study acted as a comprehensive indoor environmental quality analysis of a selected set of 19 Appalachian State University classrooms that met a specific typology. The study focused primarily on daylighting and occupant density data, but also recorded other environmental quality factors of each room, including finishes and furniture. The data gathered was compared against industry standard values for both daylighting and occupant density. The intention of the study was to act upon a set of goals that Appalachian State University had set forth as a part of its strategic plan, *The Appalachian Experience: Envisioning a Just and Sustainable Future*.

The study found that Appalachian State University classrooms that possess windows fare well in terms of daylighting. Among this sample of classrooms, however, nearly a third do not contain windows and thus do not meet daylighting standards. Nearly all classrooms observed do follow industry standard guidelines for occupant density.

The study concluded with recommendations for future classroom design to better adhere to industry standards and to increase the well-being of classroom occupants, followed by suggestions for future research.

Keywords: daylighting, indoor environmental quality, occupant density, space, planning, illuminance, sustainable design

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CHAPTER 1: INTRODUCTION

Introduction

This study examined a variety of indoor environmental quality (IEQ) attributes in classrooms across the Appalachian State University campus. The study focused on daylighting (the ability for natural light to enter the room) and the amount of space allowed per occupant, and compared these values to accepted standards. Other IEQ attributes were documented and examined but not compared against existing data. A specific typology of classroom was selected for the sample, and the measured data were analyzed against accepted standards. This effort was primarily influenced by the 2014-2019 Strategic Plan of Appalachian State University, which states that the university should “create rich environments where students can thrive” (Appalachian State University [ASU], 2015, para. 2).

Statement of the Problem

Appalachian State University takes pride in its green ethos and having a sustainable mindset (ASU, 2015). This commitment to sustainability encompasses environmental, economic, and individual sustainability and well-being (ASU, 2015) and extends to all campus functions, including buildings operations. Daylighting was the main source of light in buildings until the 20th century, when electric lighting became available and more reliable (Lechner, 2001). Since the transition to artificial light, however, studies have shown that humans not only prefer natural light (Aries, 2015) but are more productive and healthy when exposed to it (Boubekri, 2007). Although the 2015 North Carolina (NC) Building Code requires a certain amount of glazing per floor area, this legislation was adopted mostly to address egress and natural ventilation

requirements (Boubekri, 2008). Legislation is sorely lacking with respect to natural lighting in buildings, even though various studies have shown a relationship between daylight exposure and human health (Aries, 2015). The United States Green Building Council (USGBC) developed a daylighting section in its Leadership in Energy and Environmental Design (LEED) certification program, which has officially recognized daylighting as a factor in the sustainable design of buildings. The 2015 NC Building Code also requires a certain number of square feet of glazing per occupant in residential dwellings, but these requirements also focus on egress or ventilation and not necessarily on human health or comfort (International Code Council [ICC], 2012). As a leading member in the realm of sustainability in higher education (AASHE, 2015), it is imperative that Appalachian State University continues to take these types of indoor environmental quality factors into consideration when designing new buildings or renovating existing campus facilities.

Purpose of the Study

This study attempted to examine the current state of the classrooms at Appalachian State University by analyzing various components of indoor environmental quality (IEQ) and comparing them to accepted standards. The primary focus of the study was to evaluate the amount of daylighting provided in these classrooms, as well as the amount of space allowed per occupant, and compare these values to those required by the United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) certification program, and by the State of North Carolina Higher Education Comprehensive Planning Program (NCCPP), respectively. Additional factors that affect IEQ were also documented and analyzed, including date of collection, time of day for collection, square footage of room, ceiling height, area of glazing, WFR, orientation of classroom, orientation of building, age of building, year of last renovation (if applicable), floor type/color, wall type/color, general cleanliness,

noticeable wear and tear on walls, number of seats, type of seating, quality of seating, other furniture, type of windows, and other. The study aimed to understand better the current state of such classrooms to guide future construction and renovation projects at the university.

Research Questions

1. How do Appalachian State University classrooms compare to LEED standards in regards to illuminance in classrooms?
2. How does Appalachian State University compare to determined standards in regards to the amount of space per occupant in classrooms?
3. How do the different classroom spaces across the Appalachian State University campus compare with each other in terms of lighting, space, and other IEQ factors?

Definition of Terms

Important Acronyms and Definitions

Wall-to-floor Ratio (WFR): the ratio of glazing to the floor area, calculated by dividing the floor area (in square feet) by the glazing area (in square feet).

Indoor environmental quality (IEQ): refers to the quality of a building's environment in relation to the health and wellbeing of those who occupy space within it. IEQ is determined by many factors, including lighting, indoor air quality (IAQ), acoustics, aesthetics, and more.

Acoustic ceiling tile (ACT): a drop ceiling system composed of tiles typically made of mineral fiber that allows for access to building infrastructure.

Quality of Finishes Standards

Poor: The finish has many visible blemishes, stains, rips, cracks, or missing components in a variety of places throughout its entirety. Totals 10 or more major cosmetic or structural problems. Needs immediate attention or repair.

Fair: Has between five and ten visible blemishes, stains, rips, cracks, or missing components in a variety of places throughout its entirety, but does not require immediate attention.

Good: Has few (between three and five) visible blemishes, stains, rips, cracks, or missing components in a variety of places throughout its entirety.

Very Good: Has one or two visible blemishes or stains and is not ripped, cracked, or missing components.

Excellent: Has no visible blemishes or stains and is not ripped, cracked, or missing components.

Limitations of the Study

One of the main limitations of the study is that it examined classrooms of a specific typology. The classrooms studied were only “Type 110- General Classroom” rooms, which have been coded as such by the North Carolina Comprehensive Planning Program. Due to classrooms under analysis all being of a specific capacity and type, spaces such as offices and lecture halls were not considered. The University has a large number of these types of spaces as well, so analysis of these spaces would be a useful topic for future study. On the other hand, the classroom serves as the central point for instruction, which is the foundation of activity in higher education. The classrooms examined during the study provide a representative sample of the majority of educational spaces students occupy during their education at Appalachian State University.

Another limitation of the study is that not every aspect of IEQ was analyzed in this document. In order to do a more comprehensive analysis, a number of other factors could potentially be examined. These other factors include ventilation, use of artificial light, and particulates in the air. The main constraint for this study was time, but the researcher took precautions to develop a replicable data collection protocol for use in the future.

The sample size of the study also constituted a limitation. There are approximately 200 classrooms in the Type 110 classroom typology at Appalachian State University, narrowed to a sample of 20 that fit the capacity, square footage, and other guidelines as proposed by the study.

Significance of the Study

Sustainability is an integral part of Appalachian life (ASU, 2015). As a leader of sustainable initiatives and operations, Appalachian should continue to serve as a model for other institutions. This study examined sustainable building design factors in selected campus buildings to provide the groundwork for future examination of IEQ as a necessary component for building design. These findings may also inform the process of identifying campus priorities for the renovation of buildings. Although Appalachian has already committed officially to pursuing LEED certifications for all newly constructed buildings in the future (Sustain Appalachian, 2016), other universities are not necessarily pursuing such a progressive agenda. The study gives other universities the opportunity to examine the efforts Appalachian has taken with its buildings, both new and old, to promote a holistic ideal of sustainability. This holistic goal includes not only building efficiency and reliance on renewable energy sources, but also occupant health and comfort. This trend in the building industry is sure to show growth in coming years under new regulations and environmental standards, and the entire University of North Carolina system could potentially lead the country in university building design innovation.

CHAPTER 2: REVIEW OF LITERATURE

Indoor Environmental Quality

IEQ is a comprehensive description of the conditions of a space that affect the occupants who occupy the space, in terms of their physiological health and well-being (National Institute for Occupational Safety and Health [NOISH], 2015, para. 1). A number of factors affect the environmental quality of a space. Some negative influences may be prevented by design, but some cannot. Other aspects must be controlled by occupant behavior, site location, and other factors.

It is estimated that modern humans spend somewhere between 80% and 90% of their time indoors (The Association for the Advancement of Sustainability in Higher Education [AASHE], 2010). In recent years, studies have shown that low IEQ can have a negative impact on occupant health, well-being, and productivity (Al horr et al., 2016). Accompanying these outcomes is occupant comfort. We as humans have set out to create comfortable environments in which to live, work, and play. It seems as though somewhere along the way functionality, cost, and aesthetics began to dominate design over comfort. We started building with materials that were filled with chemicals. We started smoking in our living spaces. We started sealing up our houses so tightly that the air became stagnant. Soon after, problems such as sick building syndrome began to surface, where occupants were getting physically sick from the buildings in which they live and work (NOISH, 2015, para. 1).

As previously stated, IEQ is impacted by a number of factors. These factors include, but are not limited to, lighting (both natural and artificial), acoustics, air quality, thermal comfort,

space perception, and more. Indoor air quality (IAQ) is probably the most significant factor, because it has the greatest influence on human health. IAQ is influenced by the presence of radon, asbestos, cigarette smoke, pets, and volatile organic chemicals (VOCs). All of these factors play a large role in the health of the inhabitants, but can also impact mental well-being (NOISH, 2015, para. 2).

The largest factor in maximizing indoor environmental quality is the understanding of negative contributors and their sources. Most of the time, building design and construction are not the only factors leading to low IEQ. A combination of policy, design, site selection, occupant behavior, and other factors will ultimately alter the state of conditions within a space (Godish, 2001). In terms of IAQ, building design alone can have a large impact. Materials with low-VOCs, proper ventilation, and construction methods are all associated with the composition of indoor air that occupants breathe. When it comes to occupant comfort, design can also play a large role. Proper daylighting strategies, occupant control over thermal comfort, acoustics, and use of space all play a part in comfort (Godish, 2001) and can be determined by thoughtful and purposeful building design.

Daylighting

For thousands of years, humans have relied on the sun to light their living spaces (Boubekri, 2008). In fact, daylighting was the main source of light in buildings until the 20th century, when electrical lighting became available and more reliable (Lechner, 2001). The sun was not only a religious and spiritual presence but the leading factor in the design of buildings. Nearly all ancient civilizations associated architecture and city planning with the light energy that the sun provided. Partially underground dwellings utilized a south-facing cliff to ensure the maximum amount of daylighting while also providing protection from the elements. The sun

served as a source of both light and heat, and the design of the building was integral to maximizing use of available solar energy (Boubekri, 2008).

With the Industrial Revolution came a rise in population density. The immense population increase in small areas caused buildings to be built primarily for protection from the elements, which changed the relationship between architecture and the sun. Buildings were built vertically, increasing density; cities became incredibly unhealthy areas; and disease began to spread. Even as the conditions led to extremely unsanitary conditions, the lack of sunlight was a notable factor (Boubekri, 2008). This increase in density also made daylighting a more difficult task, making providing light for a variety of tasks nearly impossible (Dubois, Demers, & Potvin, 2007).

New urban planning strategies eventually surfaced, but the importance of daylighting and proper planning was not integrated into mainstream design and planning until the mid-19th century. The turn of the 20th century saw a totally new type of architecture, drawing on ancient concepts that utilized larger windows and solar energy as part of the building (Boubekri, 2008).

Light exerts several important impacts on the physiological state of the human body. According to Boubekri (2008), light affects our bodies primarily in two ways: first, by interacting with our eyes, light can alter our metabolism and endocrine and hormone systems; second, light interacts with our skin to produce Vitamin D. The first impact plays a major role in our biological clock and the energy that is released into our body. This “body clock” affects the amount of serotonin and melatonin that our endocrine system releases (Boubekri, 2008), which in turn changes the way we feel. In fact, disturbances in this body clock controlled by the natural cycle of light can even cause seasonal depression, known as Seasonal Affective Disorder (aptly and notably abbreviated as SAD), that many humans develop in high latitude climates (Boubekri, 2008).

Throughout her book titled *Daylighting for Sustainable Design*, Mary Guzowski (2000) explores in exhaustive detail the methods to optimize daylighting. She emphasizes the importance of the site and natural conditions to architectural design in order to maximize daylighting in sustainable architecture. The book provides a holistic view of daylighting and all of the tools one should employ to implement it. One particular chapter addresses both the technological and architectural approaches to daylighting, and the importance that both play in the use of light. As she states, “Daylighting objectives are first stated through architectural form and then further refined through the integration of technology...” (Guzowski, 2000, p. 246). She goes on to note that architectural decisions such as shading, overhangs, orientation, and glazing can be enhanced through the technological specificities of each component. For example, it is well established in architecture that passive solar strategies such as an east-west axis orientation, minimal northern façade glazing, and maximum southern exposure can be incorporated into a design to increase daylight. Technological innovations such as light pipes, solar concentrators, or heliostats may also be deployed to increase daylighting (Guzowski, 2000). Even with these advancements in technology, building orientation and glazing design can be the most effective strategy at allowing daylight to enter a space. Due to crowding and urbanization however, it is becoming increasingly difficult to allow light into the deep interior of buildings (Dubois, Demers, & Potvin, 2007).

Advancements in glazing technologies have led to more daylighting opportunities. Windows are no longer considered strictly as something that will let heat out or ruin a building envelope. Windows are getting better and better at insulating and are therefore being used more as a daylighting strategy (Guzowski, 2000). Technologies such as low-emissivity windows, gas-filled cavities, and HVAC-integrated window systems are paving the way for more use of glazing in a building design (Guzowski, 2000). Windows seem to be the primary option when it comes

to daylighting strategies and are being developed rapidly to increase light infiltration as well as energy efficiency.

Although studies have shown a strong relationship between daylighting and occupant health, daylighting legislation is lacking (Boubekri, 2004). This may be due in part to the unique and dynamic characteristics of daylight, such as its chromatic spectrum, changing illuminance, and regional differences. Such characteristics mean daylighting can be an extremely complex issue, which can deter legislative action. For example, federal legislation requires all habitable rooms to have a minimum illumination level of six foot candles over the area of the room, but this does not necessarily need to be met with purely natural lighting (Boubekri, 2004). Much of the current legislation offers recommended (rather than required) practices. An example of this is the IESNA RP-5-99 in the US, which provides basic design aids and strategies for controlling light level and glare (Boubekri, 2004).

CHAPTER 3: RESEARCH METHODOLOGY

Overview of Research Design

This was a descriptive study of the IEQ characteristics of selected classrooms on the campus of Appalachian State University. A variety of data were collected detailing the IEQ features of the specified classroom typology. The data gathered provided a relatively comprehensive portrait of occupant conditions within the classroom space, with a focus on daylighting and occupant density. Once collected, the data were compared against recommended standards, as defined above.

Sample

The collection of rooms examined was selected from the population of approximately 200 classrooms across the entire Appalachian State University campus. First, a list of buildings on campus was narrowed to buildings that are primarily used for academic space and narrowed further to buildings directly situated on the main campus in Boone, North Carolina. Next, all of the rooms in each of the buildings were narrowed to a selection of rooms coded 110: General Classroom by the North Carolina Higher Education Comprehensive Planning Program. The researcher then contacted various members of the university community who had access to the classrooms, typically administrative assistants in the department(s) housed in the building. These individuals were asked to identify the “most requested” classroom in the building. If they identified more than one room, the list was further narrowed based on occupancy. Where possible, the occupancy of the room selected was between 15 and 40 occupants, unless no room in the building met that criterion. This narrowed the study to 20 classrooms. It should be noted

that Room 114 in Belk Library was no longer included in the study due to the occupancy being a major outlier, creating a sample of 19 total classrooms.

Data Collection Strategies

From the final sample of rooms that met the average classroom typology selected for this study, a variety of data were collected. In regards to daylighting, the process for recording data points adhered to the following methodology:

1. Measure length and width of room in feet and inches.
2. Mark out a 10 feet by 10 feet (10'-0" x 10'-0") grid for data points.
3. Turn off artificial lighting.
4. Open blinds or other brightness control devices.
5. Take illuminance readings on a measured grid with university-owned Extech meter in foot candles (fc) units.
6. Record all measurements on marked grid and in Excel spreadsheet.
7. Measure length and width of all glazing to obtain total glazing area.
8. Divide glazing area by the floor area (as obtained from data provided by Art Rex, Director of Space Management and Planning at Appalachian State University) to obtain the WFR.

The time of day to take daylighting measurements fell between 9:00 a.m. and 3:00 p.m., as required by LEED for Schools and LEED Building Design and Construction Credit 8.1 requirements. All daylighting measurements were taken on clear, sunny days.

To analyze space per occupant, the following steps were followed:

1. Obtain maximum capacity of room from data provided by the ASU space use planner.
2. Count number of seating stations present in room at time of observation.
3. Obtain the square footage of room from data provided by the ASU space use planner.

4. Measure square footage of room with a tape measure, or by counting ceiling/floor tiles when a tape measure is not suitable for an accurate dimension.
5. Calculate occupant density by dividing the square footage by the number of seating stations.
6. Compare both occupant density values to the minimum allowable by the North Carolina Comprehensive Planning Program.

The rest of the data gathered were observational and were recorded on a form (see Appendix A). These data points included date of collection; time of day for collection; square footage of room; floor area; ceiling height; area of glazing; WFR; orientation of classroom; orientation of building; age of building; year of last renovation; floor type/color; wall type/color; general cleanliness; noticeable wear on walls; number of seats; type of seating; quality of seating; other furniture; type of windows; and other. In the “other” category, observations such as views, room walkability, type of artificial lighting, and so on was recorded.

Data Analysis Procedures

Overall quality of each room was noted. The two quantitative data sets (illuminance levels and occupant density) were compared against the values provided by LEED and the State of North Carolina Higher Education Comprehensive Planning Program. The percentage of data points that met LEED guidelines and the percentage of rooms that met the State of North Carolina Higher Education Comprehensive Planning Program were determined.

CHAPTER 4: RESEARCH FINDINGS

Selected Classroom Case Study Results

Anne Belk Hall Room 251

Built in 1968 and renovated in 2005, Anne Belk Hall is one of the older buildings on campus; the building was erected concurrent with seven other campus buildings during a boom in construction in 1968. This followed the expansion of Appalachian from a teacher's college to a university in 1967. Anne Belk Hall now houses the Departments of Anthropology, History, and Government and Justice Studies. It also contains the Center for Academic Excellence, the Office of Disability Services, IT Support Services, and University Communications. The building houses a variety of offices, classrooms, and professional conference rooms.

Observational features. Room 251 of Anne Belk Hall was observed to be in very good condition overall, which is notable considering the age of the building. The room was renovated in 2005, and contained modern furniture and finishes. The room is on the main level of the building, and is located on a main hallway near the entrance. All of the walls are interior.

Layout and configuration of room. The room measures 36 feet long by 22 feet wide, totaling 792 square feet of area. The ceilings are nine feet tall, totaling 7,128 cubic feet of volume. The length and width of the room equate to a proportion ratio of 1.636, by far the closest to the golden ratio of 1.618, with only a 1.1% calculated deviation. The tables and chairs were arranged into a large U shape, an arrangement intended for group discussion. The height of the U ran parallel with the longitudinal axis of the room, with the open end toward the lecture position.

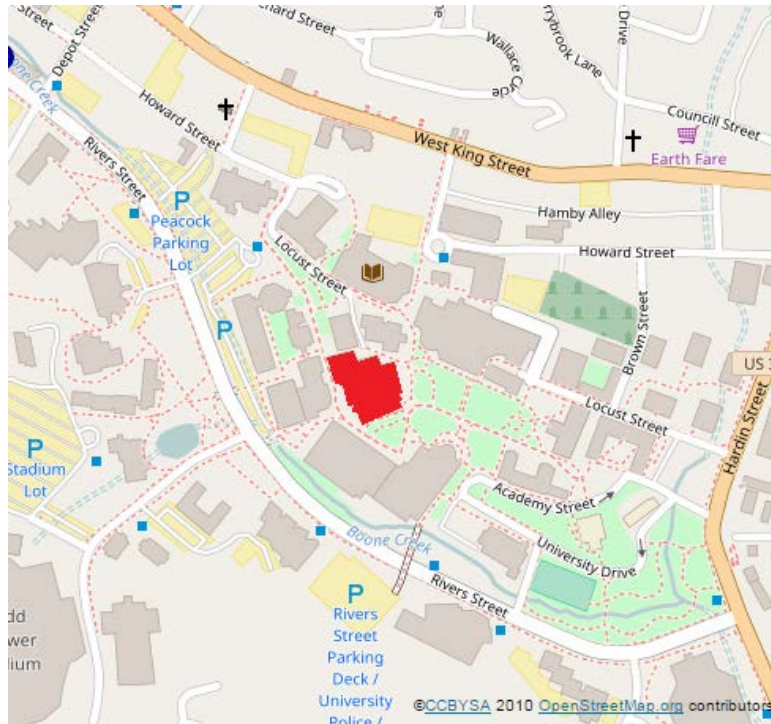


Figure 1: A campus map with the location of Anne Belk shaded in the middle segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 2: Panorama from main entrance of Room 251 in Anne Belk Hall.

Finishes. The room had a dark, multicolored carpet that was clean and well-maintained. The walls were gypsum wall board painted off-white, with a few scuffs marks, and overall in good condition. The ceiling consisted of 2 foot by 2 foot white ACT with few moisture stains.

Seating and occupant density. The room had a total of 26 seats at the time of observation, four less than the maximum capacity of 30. This number of actual seats equates to an occupant density of 30 feet per occupant, far above the recommended space of 18 square feet per occupant at a 50% positive difference.



Figure 3: Chairs in Anne Belk classroom.

The desks were long and narrow, measuring approximately 18 inches wide by 6 feet long. They had metal legs and laminated tops and were in very good condition. The chairs were mostly plastic with metal hardware (Figure 3). The seat and back were pale green and the legs were black. The chairs were sleek and modern and all were in very good condition.

Natural lighting strategies. The room did not contain any windows or alternate daylighting technology.

Artificial lighting strategies. The room contained eight T8 fluorescent troffers, all of which were in working condition.

Ingress/Egress. The classroom had one 3 foot by 7 foot door that exits to a main hallway, totaling 3 feet of egress. The room had no additional doors that enclosed a closet or storage area.

Other furniture, fixtures, and equipment. The room occupants did not have control over the thermal comfort of the room. The room did not appear to have a separate air conditioning unit, and was most likely run on the same HVAC system as the rest of the building, meaning the room had no access to cool air in the summer.

The room also contained two white boards, a smart podium, a projector, and screen.

Unique qualities and other observations. The room did not have any major defining features that would set it apart from other rooms observed in the study. It was in very good condition due to a recent renovation of the building in 2005.

Daylighting Results. Due to the absence of windows in the classroom, there are no results for this section of the study.

Appalachian Hall Room 161

One of the newest buildings on campus, Appalachian Hall serves as both a dorm and a lecture space, and houses the Honors program students. The building was built in 2013, and was in the best condition overall of all the classroom buildings examined in this study. The building contains six classrooms, all coded 110, and all with a maximum occupancy of less than 25 students. All six classrooms had windows to the exterior as well.

Observational features. Of all the classrooms observed in this study, room 161 in Appalachian Hall was the most unique. The building is the newest observed in the study, and its young age was shown in various areas, including lighting sensors, quality of finishes, and overall design. Room 161 is located on the ground level of Appalachian Hall, with three interior and one exterior, south-facing wall with large windows.

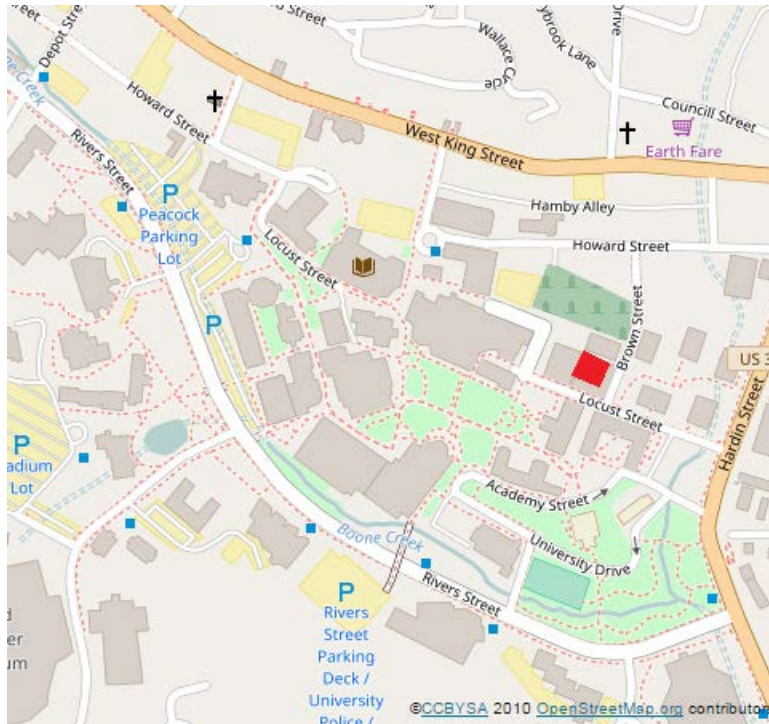


Figure 4: A campus map with the location of Appalachian Hall shaded in the middle-right segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 5: Panorama image from main entrance of Room 161 in Appalachian Hall.

Layout and configuration of room. This room was one of the smallest observed in the study, with dimensions of 18 ½ feet by 18 feet, totaling 333 square feet of space. The height of the room ranges from 12 feet to nearly 16 feet, equating to around 4,500 cubic feet of volume. The ratio of room dimensions equals approximately 1.03, with a 36.34% deviation from the golden ratio. The longitudinal axis runs from east to west, allowing the longer south wall to be

on the exterior. The desks were arranged in a U-shape at the time of the study, with the opening of the U facing the eastern wall.

Finishes. The floor finish was a modern multicolored carpet with abstract designs in dark browns, greys, and tans. The carpet was in excellent condition with no visible stains, rips, or snags. The walls were gypsum wall board, the bottom half being white, and the upper half a bright yellow. The walls also had no obvious impurities. The ceiling finishes varied, with concrete, white ACT, and gypsum wall board panels, all of which were in pristine condition.

Seating and occupant density. The room has a maximum seating capacity of 20 persons, and it held a total of 14 seating stations at the time of data collection. The actual seating count allowed for 23 square feet per occupant, while the maximum capacity allows for only 16 square feet per station. This equates to a positive 11.68% difference than the recommended space per occupant of 18 square feet.

The classroom contained six long tables with fold-up metal legs and laminate tops. The tables measured 2 feet wide by 6 feet long and all were in excellent condition. The seating in the room consisted of more modern desk chairs (Figure 6), with tan upholstery and red metal frame and legs. All of the seats were in excellent condition, with no signs of stains or damage.

Natural lighting strategies. The room has one wall with a large area of windows, most of which are fixed windows. There were two small side-by-side awning windows at the bottom of the configuration that measure 1 foot high by 5 feet wide. The entire window configuration measures 16 feet wide by 10 feet tall, totaling 160 square feet of glazing. This contributes to a WFR of 48.04%.



Figure 6: Chairs in Appalachian Hall classroom.

Artificial lighting strategies. The room contained two commercial suspended LED fixture rows, each approximately 10 feet in length. The lower section of ceiling on the northern side of the room also contained recessed can lighting. All fixtures appeared to be in good working condition. The room contained either an occupant sensor or lighting timer, but also had manual controls.

Ingress/Egress. The room had only one door, measuring 3 feet by 6 feet-8 inches, totaling three feet of egress. There were no additional doors to closets or storage rooms in the classroom.

Other furniture, fixtures, and equipment. The room did not appear to have any occupant controls over thermal comfort other than the small awning windows. The room did have HVAC supply and return ducts with registers running across the top of the room. The small windows are likely used for additional ventilation in the summer months, but many new buildings on campus are centrally controlled and less likely to have occupant controls in each room.

Unique qualities and other observations. As previously stated, this room was the most unique of those observed in the study. Being the newest building on campus, this was somewhat expected, but the actual design of the room came as a surprise. It had a much more contemporary industrial feel, with concrete accents and exposed HVAC. It was also in the best condition of all the rooms observed – even compared to Beasley Media Complex room 224 – which was constructed the same year.

Daylighting Results. The classroom meets LEED requirements in five of the six data collection points, as shown in Table 1.

Table 1 <i>Daylighting Measurements in Appalachian Hall Room 161</i>			
6 feet increments in this direction			
10 feet increments in this direction	199 fc	5640 fc - HIGH	379 fc
	50 fc	80 fc	68 fc
	Main entrance of room location		

Beasley Media Complex Room 224

Constructed in 2013, the Beasley Media complex is an 18,000 square foot facility that also contains university parking. The space serves as a broadcasting facility and lecture space for the Department of Communications and WASU radio station, but also contains three code 110 classrooms. The building stands on land once occupied by a local bus depot, and utilizes old stones that recovered during demolition as part of the new façade.

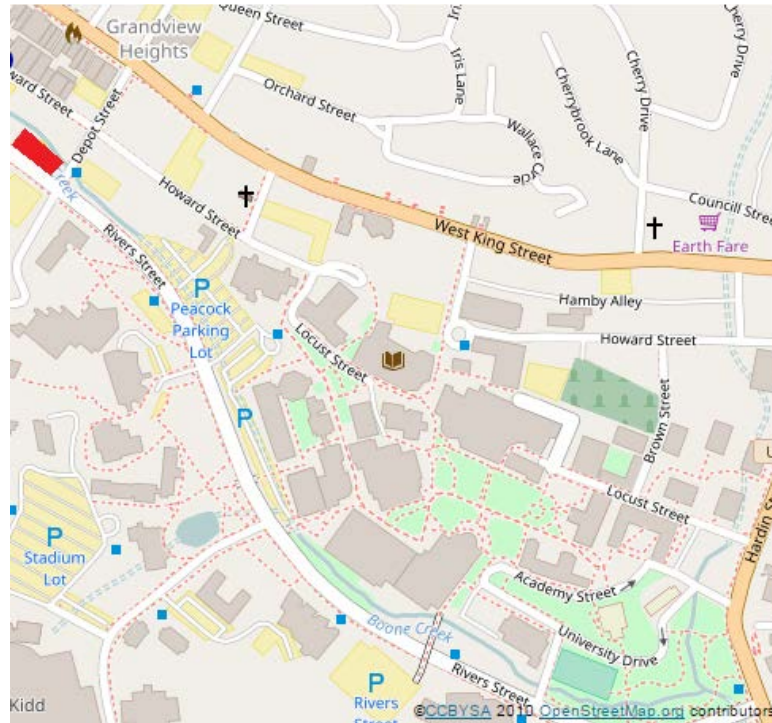


Figure 4: A campus map with the location of Appalachian Hall shaded in the middle-right segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 8: Panorama image from main entrance of Room 224 in the Beasley Media Complex building.

Observational Features. Another very new classroom on campus, Beasley Media Complex room 224 was in very good condition. With south facing windows, new furniture, and three brightness settings for the lights, the room embodied “new” without sacrificing typical

classroom design. Everything appeared to be in excellent working condition. The room is situated on the second level of the complex, with three interior and one exterior, south-facing wall.

Layout and configuration of room. The room measures 24 feet wide by 34 feet long and the longitudinal axis runs from east to west, allowing for more windows on the south-facing wall. These dimensions total 816 square feet of space, one of the largest observed in this study. The proportions equate to a ratio of 1.417, a 12.3% deviation from the golden ratio.

The desks in the room were arranged in rows of two, facing the lecture position on the eastern wall. There were more rows on the south side than there were on the north side, with four seating positions in each row.

Finishes. The carpet was a modern print carpet of tans and browns in excellent condition with no visible stains, rips, or tears. The walls were a pale yellow-tan painted gypsum wall board and were also in excellent condition. The ceiling was white ACT with no visible signs of moisture damage, missing panels, or rips.

Seating and occupant density. The room capacity is listed as 35 occupants, and the observer counted 30 chairs in the room at the time of observation. With the measured area of 816 square feet, this equates to 23 square feet per occupant at maximum capacity and 27 square feet with the current configuration of chairs. These values are both well over the recommended value of 18 square feet per occupant for this classroom type, with the measured value producing a positive 40% difference.

The desks in the room were a standard metal frame and wood laminate top, with fold-up legs. All were in excellent condition with no peeling laminate. The chairs had a black metal frame and black plastic seat and back (Figure 9). All of the chairs were of the same style and color and all were in excellent condition.

Natural lighting strategies. The room possessed three 5 foot by 5 foot fixed windows with aluminum trim and mullions. This totals 75 square feet of glazing on the south wall of the room with views of Rivers Street and the Student Recreation Center. This amount of glazing equates to a WFR of 9.19%. The windows also appear to have a tint coating to assist with glare in the afternoon sun.



Figure 9: Chairs in Beasley Media Complex classroom.

Artificial lighting strategies. The artificial lighting in the room consisted of what appeared to be T8 fluorescent troffers. The lights had three brightness settings, 30%, 50%, and 100% controlled by switches at both entrances. All lights were in working condition and no bulbs appeared to need replacement.

Ingress/Egress. The room had two entry and exit doors, both measuring three feet in width. This equates to a total of six feet of egress. There were no additional doors in the room that lead to storage closets or similar areas.

Other furniture, fixtures, and equipment. Although the room appeared to be thermally controlled by the building's central HVAC system, the occupant did not have any additional control. The windows have very dark shades that can be pulled to reduce glare and thermal gain in warmer months, and were fixed windows that cannot be opened.

The room had a smart podium, screen, and projector combination, and white boards at the front of the room. It also had a printer and additional office equipment near one entrance.

Unique qualities and other observations. The room did not have any major defining qualities as observed by the researcher. The walls were painted entirely yellow, making this the only classroom with four non-neutral walls. It was also quite a bit larger than the median classroom size of 762 square feet of area. It was one of the few rooms with non-operable windows.

Daylighting results. The classroom meets LEED guidelines at all four data collection points as shown in Table 2.

Table 2 <i>Daylighting Measurements in Beasley Media Complex Room 224</i>		
	10 feet increments in this direction	
10 feet increments in this direction	76.7 fc	88.6 fc
	49.8 fc	51.8 fc
	Door location	Door location (as seen from Figure 8)

Broyhill Music Center Room 206

The Broyhill Music Center was constructed in 1983 and renovated last in 1993. The center currently serves as a music education facility, with an assortment of lecture halls, recording facilities, auditoriums, and practice rooms. Because of the variety of use for the spaces, the Broyhill Music Center only contains four coded 110 classrooms.

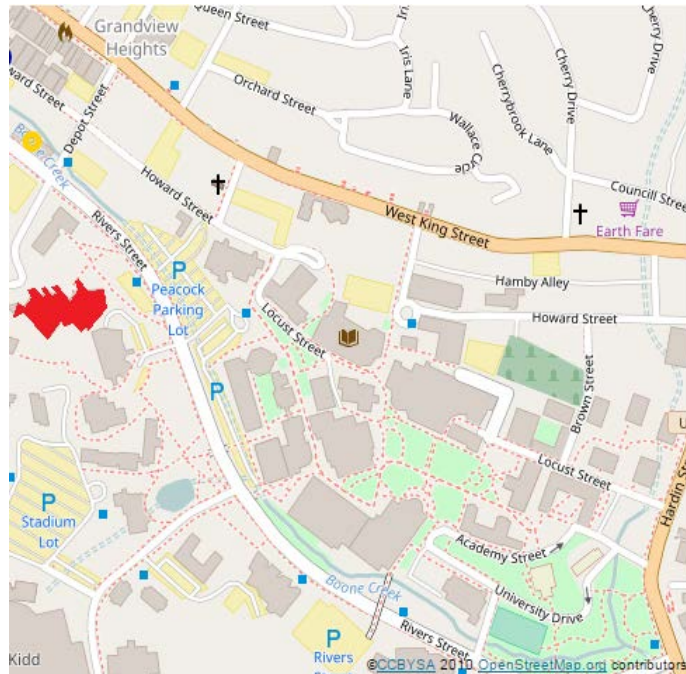


Figure 10: A campus map with the location of the Broyhill Music Center building shaded in the middle-right segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 11: Panorama image from main entrance of Room 206 in the Broyhill Music Center building.

Observational features. This classroom falls into the average classroom design typology as observed by this study. With no windows, grey carpet, and white walls and ceiling, it would be impossible to guess the location and use of the room if it weren't for the white boards on every wall with music scales drawn in permanent marker. Located nearly in the center of the

building, on the second floor, all four walls are interior. Overall, the room was in good condition, with some visible wear on finishes and furniture.

Layout and configuration of room. The room measures 21 feet wide by 28 feet long with 9 feet high ceilings. This equates to 588 square feet of floor area and a dimensional ratio of 1.33, a 17.8% deviation from the golden ratio.

The desks in the room were arranged in six columns of 5 each, facing one of the long walls in the room. Because the desks were individual, it would be difficult to rearrange them into an entirely different configuration.

Finishes. The floor covering in the room was a dark multi-toned carpet and was in fair condition. There were several visible stains at the time of observation. The walls were standard CMU block painted off-white. Whiteboards wrap the entire perimeter of the room, covering almost as much area as the CMU. There were several scuff marks, but no evidence of major wear that could harm or distract occupants. The ceiling was white ACT, with a couple visible moisture stains, but no tears or additional damage.

Seating and occupant density. The seating in the room consisted of chair-desk combination pieces as seen in Figure 12. The frames were metal, the seats were yellow plastic, and the desk was a laminated composite material with an off-white top (see Figure 12). All of the seats appeared to be in good condition, with little to no visible wear.

The researcher observed 30 desk-seat combinations in the room, whereas the maximum capacity was listed as 33. If seated at maximum capacity, the room allows for 17 square feet of area per occupant (less than the recommended average of 18 square feet per occupant), but with the current number of seats of 30, this space would increase to 19 square feet per occupant and a positive 5.41% difference from the recommended value.



Figure 12: Seating in the Broyhill Music Center classroom.

Natural lighting strategies. The room did not contain any windows or alternate daylighting technology.

Artificial lighting strategies. The lighting in the room consisted of nine T8 troffers with fluorescent bulbs, which were all in working condition. The lights were operated by two, three-way switches located at each entrance.

Ingress/Egress. The room had two doors which both measure 3 feet in width, totaling 6 feet of egress. One door was located off a main hallway, while the other was located on an adjacent wall into a side-hallway.

Other furniture, fixtures, and equipment. The room did not appear to have any occupant control over thermal comfort or additional ventilation to the exterior of the building. As is with many classrooms, the room possesses a smart podium, projector and screen, and a desk at the front of the room. There were also two large speakers facing the seated occupants at the front of the room, above the lecture space.

Unique qualities and other observations. The main defining quality of the classroom was the number of whiteboards mounted on the walls. There were a total of nine full size (4 feet

in width by 6 feet in length) and one half-size board, wrapping the entire perimeter of the room. Another defining feature was the stand-up piano situated at the front of the room.

Daylighting results. Due to the absence of windows in the classroom, there are no results for this section of the study.

Chapell Wilson Hall Room 111

One of the oldest buildings on campus, Chapell Wilson was constructed in 1938 and renovated in 1994. The building stands out on campus with the original rock finish still intact, one of two such buildings that remain nearly untouched. Wilson Hall contains eight coded 110 classrooms, with the rest being used as auditorium and practice rooms. It is located on the western side of campus, between Peacock Hall and the Belk Library and Information Commons.

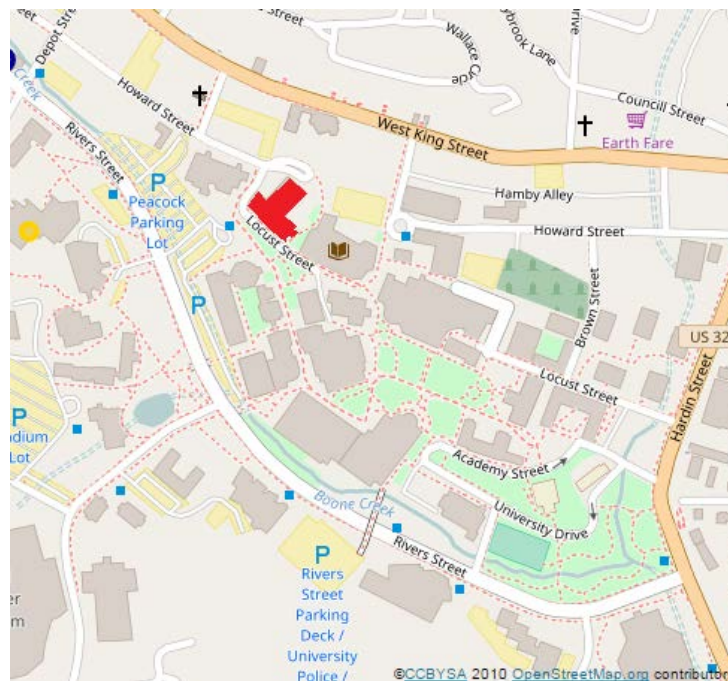


Figure 13: A campus map with the location of Chapell Wilson shaded in the middle-right segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 14: Panorama image from main entrance of Room 111 in Chapell Wilson Hall.

Observational features. Aside from a pop of color and new lighting fixtures, this room was standard overall. All finishes and furniture appeared to be in good condition, with few to no signs of degradation. The room was located on the ground floor of the building, with three interior walls and one exterior, south-facing wall.

Layout and configuration of room. The room measures 20 feet wide and 30 feet long, with the south wall being parallel with the longitudinal axis. This equates to 600 square feet of floor area and a dimensional ratio of 1.50, a 7.29% deviation from the golden ratio.

The seating in the classroom consisted of 32 chair-desk combinations. The seats were arranged in a large, two-rowed U shape, which wraps around the room and opens toward the west wall. There was an ample amount of space in the center of the classroom for the seats to be rearranged.

Finishes. The floors were finished with white speckle 1 foot by 1 foot VCT, with a pale green accent pattern near the entrance. The floors were in good condition, with little to no stains or rips. The three interior walls were white gypsum wall board, while the exterior wall was gypsum wall board painted a faint yellowish-green. All walls were in very good condition, with no visible wear. The ceiling was white ACT, also in very good condition, with no visible moisture stains or wear.

Seating and occupant density. The seating consisted of 32 chair-desk combination pieces. The frame of these pieces was metal and the seat, back, and desks were a tan plastic composite material as shown in Figure 15.

The listed maximum room capacity was 30, but the researcher counted 32 seating stations. This is one of the few buildings observed where this occurred. With the measured square footage of 600 square feet, this equates to 18 square feet per occupant with the current number of seats.

Natural lighting strategies. The room possessed a large window system that consisted of five large double-hung windows, measuring a total of 19 feet wide by 7 feet, 6 inches tall. This equals 142.5 square feet of glazing on the south wall of the room. This area produces a WFR of 23.75%. The windows face the western section of campus and a section of Rivers Street.

Figure 15: Seating in the Chapell Wilson classroom.



Artificial lighting strategies. The room primarily utilized T8 LED troffer fixtures, with one standard fluorescent fixture still in place. The lights were arranged in three rows of four (12 total fixtures), with the fluorescent T8 being directly over the entrance, which appeared to either be not working or disconnected at the time of observation. All other lighting fixtures were working properly.

Ingress/Egress. The room contained one 3-foot wide entrance door, totaling 3 feet of egress. There were no additional entrances to closets or storage rooms.

Other furniture, fixtures, and equipment. The room did not appear to have occupant access to thermal comfort, besides the external ventilation from the windows. The room also did not have a separate AC unit for use during the warmer months.

As is with most of the rooms observed in this study, the room had the following additional features: a desk at the front of the room, a smart podium, a projector, and a screen. The room also had two large chalkboards mounted on the west and north walls.

Unique qualities and other observations. The main defining quality of the room would be the color on the south wall and the pattern on the floor. The other rooms with color accents used a shade of yellow, while this wall was painted a pale green, with green tiles. The floor pattern was also the only observed tile accent across all classrooms, and the lighting fixtures were the only LED ones in an older classroom.

Daylighting Results. The classroom meets LEED guidelines in four of the six data collection points as shown in Table 3.

Table 3 <i>Daylighting Measurements in Chapell Wilson Room 111</i>			
	10 feet increments in this direction		
10 feet increments in this direction	160 fc	665 fc – HIGH	1069 fc – HIGH
	160 fc	240 fc	205 fc
			Door location (as seen from Figure 14)

D.D. Dougherty Hall Room 237

The third oldest building on campus, D. D. Dougherty Hall was once the university library. The historic building was built in 1935, and has remained almost entirely untouched. The

interior of the building was updated in 1984 in order to convert it to an administrative space. Today, it houses mostly offices and document storage, with two code 110 classrooms being used for the Military Sciences and Leadership program. The building also contains the Center for Academic Advising, Archives and Records, Learning Assistance Program, and Orientations offices.

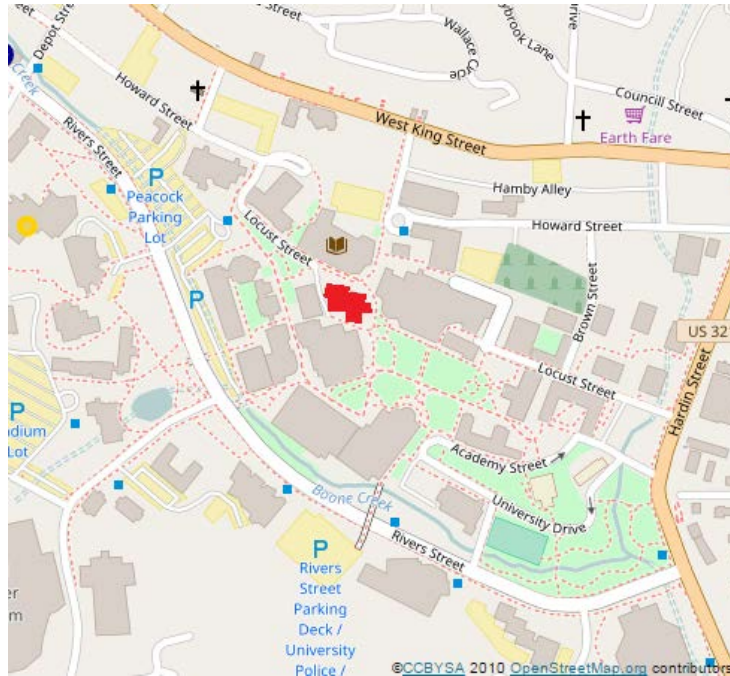


Figure 16: A campus map with the location of D.D. Dougherty shaded in the middle segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 17: Panorama shot from main entrance of Room 237 in D.D. Dougherty.

Observational Features. Although it is located in one of the oldest buildings on campus, this classroom was in overall great condition. Located on the second level of D.D. Dougherty, the classroom has three interior walls and one exterior wall on the north side of the building. The room is the largest observed in the study, with the largest allowable area per occupancy.

Layout and configuration of room. The room dimensions measure approximately 30 feet wide by 48 feet long, with the longitudinal axis being parallel with the north exterior wall. This equals 1,474 square feet of area and a dimensional ratio of 1.6, a 1.1% deviation from the golden ratio. The room also has 13 feet high ceilings, making the overall volume much greater than the other classrooms observed in the study.

The desks were arranged in two columns and two rows, facing the eastern wall. There was plenty of excess space both on three sides of the configuration and in the rear of the room for a reconfiguration.

Finishes. The floors of the room were finished with 1 foot by 1 foot VCT tile that was brown-red in color. There were no missing or broken pieces visible to the researcher. Two walls were gypsum wall board and two were painted CMU blocks. All four walls were painted two-toned with a dark grey from the finish floor to about 2 feet 8 inches in height, with a lighter shade of grey the rest of the way up the ceiling. All walls were in great condition, with little to no scuffs or wear. The ceiling was finished with 1 foot by 1 foot ACT with penetrations for air transfer between the sub ceiling and the room. The tiles were in good condition, with some raised due to pressure differentials between the outdoors, hallway, and room.

Seating and occupant density. The room contained 32 office style chairs, with a plastic frame and a cushioned seat and back (see Figure 18). The frame of the chairs was black and the upholstery was black with multicolored specks throughout the fabric. The room utilized

tables as desk spaces, which were simple and wooden. Both the tables and chairs were in very good condition, with little to no visible surface wear or damage. The chairs had more cushion than any other observed in the study and seemed fairly new.



Figure 18: Chairs in the D.D. Dougherty classroom.

The researcher counted 32 chairs at the time of observation, and the recorded maximum capacity was 28 occupants. Both values would equate to a much higher occupant density (46 square feet and 52 square feet, respectively) than the recommended 18 square feet per occupant. This results in a positive 56% difference.

Natural lighting strategies. The classroom had six double-hung windows on the north wall, each of which measured 4 feet wide by 8 feet tall. In total, this equals 192 square feet of glazing and a dimensional ratio of 13.03%. The windows had a clear view of the Belk Library and walkways on the north side of campus.

Artificial lighting strategies. Suspended from the ceiling of the room were two rows of four pendant fixtures with fluorescent bulbs. Three-way switches at each entrance operated the lights and all were functioning correctly at the time of observation.

Ingress/Egress. The room had two doors that exit into a main hallway of the building. Both of which were 3 feet in width and 80 inches in height, totaling 6 feet of egress.

Other furniture, fixtures, and equipment. The room did not appear to have occupant controls for thermal comfort other than the large windows for ventilation during warmer months. It also did not appear to have any registers or ducts, but there is the possibility of the penetrated ceiling tiles being used as a plenum for air transfer. It is unknown whether or not this is the case.

The classroom had the standard group of furniture and technology: a desk at the front of the classroom, a smart podium, and a projector and screen combination. It also had several chalkboards, and a variety of furniture located toward the back of the classroom that held a number of gadgets, toys, and tools, presumably for ROTC class demonstrations.

Unique qualities and other observations. The most obvious defining feature of the room was the VCT finish on the flooring. It was the only classroom observed in the study with a floor covering that was not entirely comprised of neutral colors. The room was also quite large for the number of seats that actually inhabited the room at the time of the study. The allowable space per occupant was much more than any other classroom observed.

Daylighting Results. The classroom meets LEED requirements in one of the six data collection points as shown in Table 4.

Table 4 <i>Daylighting Measurements in D.D. Dougherty Room 237</i>			
10 feet increments in this direction	10 feet increments in this direction		
	9.1 fc - LOW	9.4 fc - LOW	13.4fc
	3.2 fc - LOW	4.5 fc - LOW	4.4 fc - LOW
	Door Location		Door location (as seen from Figure 17)

Edwin Duncan Hall Room 313

Built in 1965 and renovated in 1988, Edwin Duncan Hall is a three-story structure consisting of 13 coded 110 classrooms, as well as a variety of office spaces. The classrooms range in occupancy from 30 to 75 students, with the average being a classroom occupancy of 35. Edwin Duncan also contains the offices for the College of Fine and Applied Arts, as well as the Department of Communication Sciences and Disorders, Department of Nursing, and Department of Social Work. The most defining feature of the building is an octagonal addition structure that contains four classrooms on the interior, with hallways and windows on the exterior. The octagon is connected to the main structure with a lounge area vestibule.

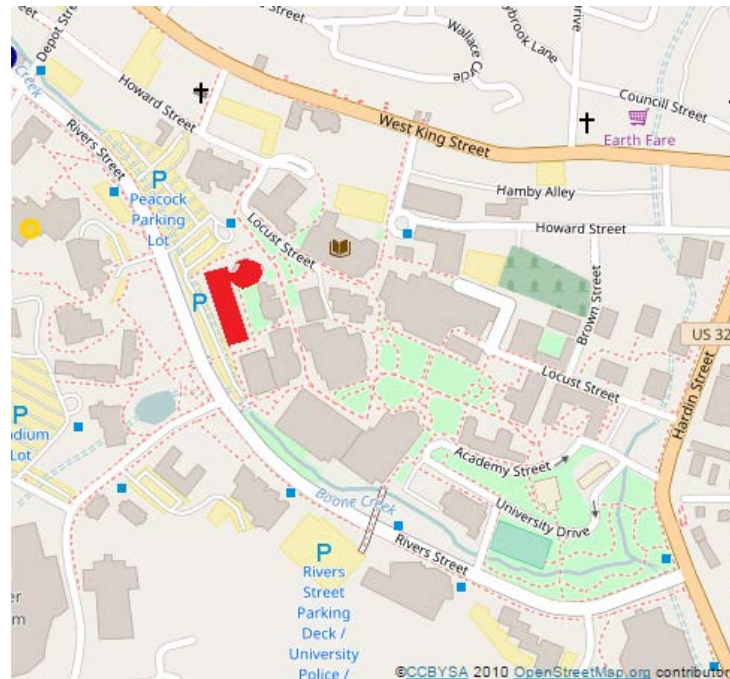


Figure 19: A campus map with the location of Edwin Duncan shaded in the middle-left segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 20: Panorama image from main entrance of Room 313 in Edwin Duncan Hall.

Observational Features. Another standard classroom, Edwin Duncan 313 is in fair to good condition overall, and has few defining features. Located on the third floor of the building, the room has two exterior and two interior walls. Although it is a corner room, only the western wall has windows. Used primarily by the Department of Sustainable Technology and the Built Environment, the room is nearly always booked for classes.

Layout and configuration of room. The room measures 32 feet long by 31 feet wide, totaling a square footage of 992 square feet. With 9 feet ceilings, the room has a volume of 8,928 cubic feet. The dimensional ratio is 1.03, a 36.34% deviation from the golden ratio. The longitudinal axis runs east to west, with the long walls being the northern and southern walls.

At the time of observation, the desks were arranged in rows facing the northern wall. Each row consisted of two long tables side by side, with aisles down the center and easterly side of the room to access all seats. This configuration does not lend itself to group discussion, but leans toward more standard lecture-style classes.

Finishes. The ceiling of the room consisted of white ACT, most of which were in fair to good condition. At least three moisture stains were visible at the time of the study, as well as ceiling tiles with small rips or tears. The floor had a dark blue-grey carpet finish in fair condition. There were visible stains and a dirt path in heavy traffic areas. Three walls were painted CMU

block, while one had a plaster finish. All walls were white, with few scuff marks and in overall good condition.

Seating and occupant density. Edwin Duncan 313 has a capacity of 40 occupants, and the researcher found this number to be equivalent to the number of seats in the room at the time. This capacity allows for approximately 24 square feet per occupant, a positive 24.57% difference from the recommended area of 18 square feet per occupant.



Figures 21 and 22: Chair types in Edwin Duncan classroom.

Interestingly, the room contained five different styles of chairs out of the 40 total. Two were most common, although the other three styles occurred at least twice. See Figures 21 through 26 for examples of each style. Most seats were in good condition, and were of the standard cushioned office chair variety. Some, such as the office chair seen in Figure 23 had stains of unknown origin or malfunctioning parts. The tables had black metal frames and white laminated tops and all were of the same style. All of the tables were in good condition, with little to no visible wear.



Figure 23: Chair type in Edwin Duncan classroom.



Figure 24: Chair type in Edwin Duncan classroom.



Figure 25: Chair type in Edwin Duncan classroom.

Natural lighting strategies. The window configuration consisted of both fixed and sliding windows, situated on the west wall of the room. The total dimensions of the configuration were 18 feet 8 inches by 5 feet 4 inches, totaling an area of roughly 99.6 square

feet of glazing. This equates to a WFR of 10.04%. The windows were operating correctly at the time of observation, with views of Raley Parking lot and western side of campus, with no obstructions.

Artificial lighting strategies. The lighting in the room consisted of nine T8 troffer fixtures with fluorescent bulbs, all of which were in working condition and operated by a switch at the rear of the room by the entrance.

Ingress/Egress. The room was only accessible by one doorway that measured 3 feet wide, totaling 3 feet of egress. The door exits into a main hallway on the third floor of the building and was in good working condition.

Other furniture, fixtures, and equipment. The room appeared to have registers to access the buildings central heating system, with no occupant controls over thermal comfort. The building does not appear to have a central air conditioning system, and there was no additional air conditioning unit in the room. The windows allow occupants to access exterior ventilation in warmer months.

At the time of observation the room had several extra chairs stacked up in the front, to be used for additional seating. It also had the podium, screen, projector combination that the other classrooms observed in the study also possess.

Unique qualities and other observations. The most unique feature of the classroom was undoubtedly the number of different chairs in the room at the time of the study. The room was standard overall, with no accent colors, unique furniture, or eye-catching finishes.

Daylighting Results. The classroom meets LEED requirements in five of six recorded data collection points as shown in Table 5.

Table 5 <i>Daylighting Measurements in Edwin Duncan Room 313</i>			
	10 feet increments in this direction		
10 feet increments in this direction	41.6 fc	39.8 fc	13.7 fc
	54.8 fc	33.85 fc	9.88 fc - LOW
			Door location (as seen from Figure 20)

Garwood Hall Room 337

Previously known as CAP (Chemistry, Astronomy, and Physics), Garwood Hall was built in 1998 and has not yet been renovated. The building holds the title as the second most expensive building examined in this study, behind the Belk Library and Information Commons (excluded from this study upon further consideration). It is second to Appalachian Hall in the price per square foot, presumably due to the abundance of specialized rooms for laboratories. Unusual for its size, Garwood only contains nine code 110 classrooms, with the majority of the rooms coded as laboratory and research spaces. Additionally, the majority of these nine classrooms are larger lecture halls, with capacities of over 50 people. Per the building’s previous

acronymic branding, the building contains the Department of Chemistry and the Department of Astronomy and Physics, as well as the Department of Computer Science.

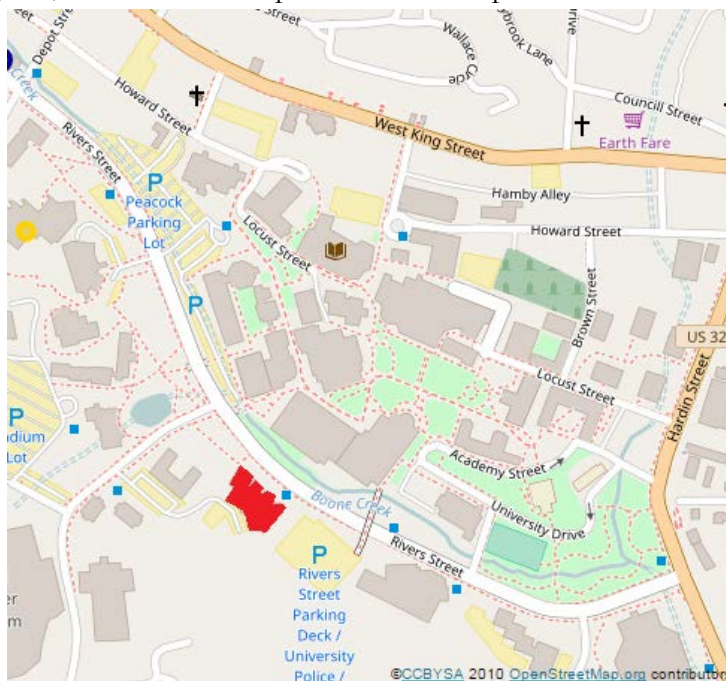


Figure 26: A campus map with the location of Garwood Hall shaded in the lower-left segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 27: Panorama image from main entrance of Room 337 in Garwood Hall.

Observational Features. This room is located on the third floor of Garwood Hall and serves as a lecture space for the Department of Chemistry. In fair to good condition overall, the room had many signs of wear on both furniture and finishes. The room is on the south side of

the building, and although it is believed to have at least one exterior wall, it possesses no windows.

Layout and configuration of room. The room measures 24 feet wide by 28 feet long, with the longitudinal axis running north to south. The area totals 672 square feet, and with 9 feet ceilings has a volume of 6,048 cubic feet. The dimensional ratio equals 1.17, a 27.87% deviation from the golden ratio.

The desks were arranged in two columns and five rows facing the northern wall of the room. The desks are semi-permanent and were bolted to the floor, with chairs that were attached and unable to be moved around (see Figure 28).

Finishes. The ceiling consisted of white ACT in fair condition. There were two tiles that were ripped in half, but still in place, and visible moisture stains. The floor had both grey and white VCT in a checkered and line pattern. All tiles were in good condition with little to no signs of wear. The walls were finished with white painted gypsum wall board and were in great condition.

Seating and occupant density. The room has a listed capacity of 45, and the researcher counted 44 seat stations at the time of the study. Two of these chairs were missing and had been replaced with wooden desk chairs (see Figure 29). One seat was broken, but still in place, and leaned backwards. With the measured area and a total of 44 seat stations, this equates to roughly 15 square feet per occupant. This is a negative 15.18% difference from the suggested 18 square feet per occupant, and the exact amount as required by the North Carolina Building Code for egress purposes in assembly areas.

As previously mentioned, the seating consisted of semi-permanent desk-chair combinations that mount to the floor of the room. The seats pivot on an arm so that they can be accessed. The seats were plastic, and the desks were plastic and laminate finish with a steel frame to support the weight of both the occupants and the desks.

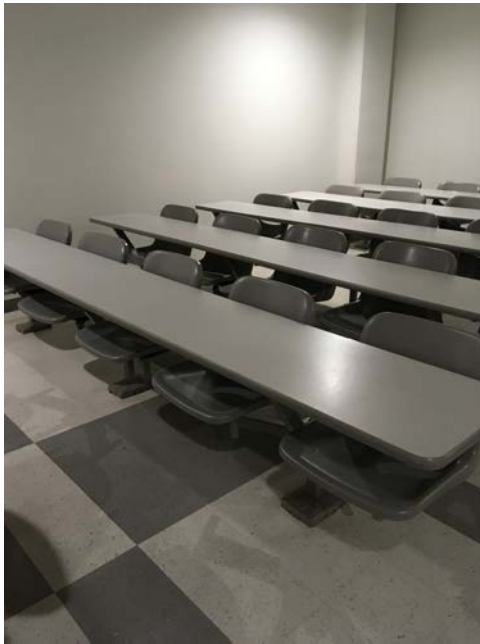


Figure 28: Seating in Garwood Hall classroom.



Figure 29: Wooden chair replacement in Garwood Hall classroom.

Natural lighting strategies. The room does not contain any windows or alternate daylighting technology.

Artificial lighting strategies. The lights in the room consisted of 12 T8 troffer fixtures with fluorescent bulbs as well as recessed can lights to control the brightness in the room. All lights were in working condition and operated by switches at the front of the room near the entrance.

Ingress/Egress. The room had one 3 feet wide door, totaling 3 feet of egress. The door opened into a secondary hallway on the third floor of the building.

Other furniture, fixtures, and equipment. The room did not appear to have occupant controls over thermal comfort but did have registers supplied by the building's central HVAC system. The room did not possess any occupant access to exterior ventilation.

The room had the standard furniture and technology package also seen in every classroom observed in the study that consisted of a smart podium, projector, and screen. The room also had a lab table at the front of the room, with a sink and mounts for scientific equipment.

Unique qualities and other observations. The room did not possess many defining features other than the lab table located at the front of the room. At the time of observation, the researcher noted the smell of chlorine or cleaning equipment and the sounds of mechanical equipment coming from the ceiling.

Daylighting Results. Due to the absence of windows in the classroom, there were no results for this section of the study.

I.G. Greer Room 219

One of the buildings on campus scheduled to be demolished in the 2020 Campus Master Plan, I.G. Greer is one of the overall lowest quality buildings examined in this study. Originally built in 1950 and renovated in 1983, the building contains a variety of office, classroom, lecture hall, and auditorium spaces. The building holds five code 110 classrooms, all of which have a capacity of over 35 students. Home to a variety of central offices, the building contains all of the following university offices and academic units: College of Arts and Sciences, Department of Philosophy and Religion, Equity Office, Office of Student Success, the Research Institute for Environment, Energy, and Economics, and the University Ombuds Office. The most defining feature of the building is the IG Greer Theater, which hosts campus movie viewings and performance practices.

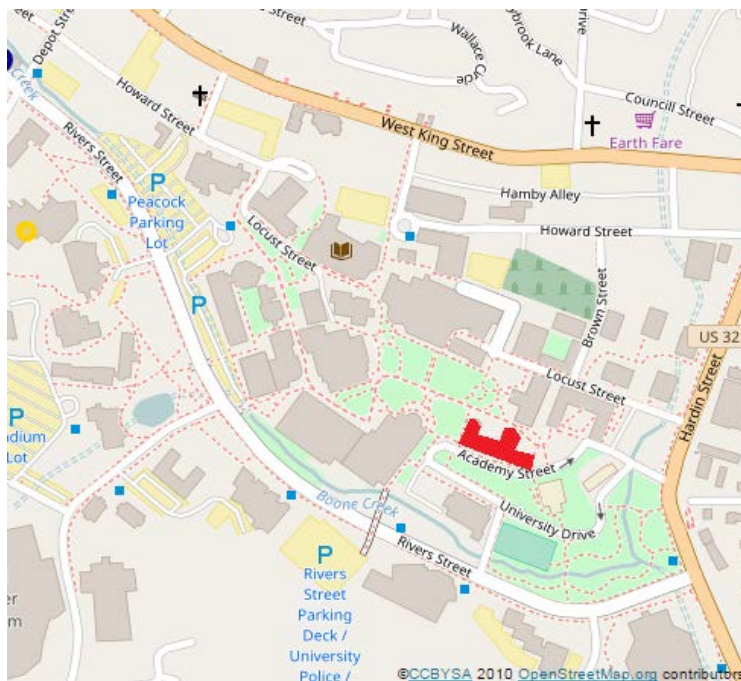


Figure 30: A campus map with the location of I.G. Greer shaded in the middle-right segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 31: Panorama shot from main entrance of Room 219 in I.G. Greer.

Observational Features. Located on the southern side of the building with a lot of windows, this room was in overall good condition. With outdated furniture and finishes, the room could use updates if it had not been located in a building that is scheduled for demolition in the campus master plan. The room has three interior walls and one exterior wall located on the south wall of I.G. Greer and serves as a lecture space for the Department of Philosophy and Religion.

Layout and configuration of room. The room measures 22 feet wide by 32 feet long, with the longitudinal axis running from east to west and windows on the southern wall. The dimensional ratio equates to 1.45, a 10.38% deviation from the golden ratio. The area totals 704 square feet, and with 10 feet 4 inch ceilings, the volume totals roughly 7,274 cubic feet.

The desks in the room are arranged in long rows, all facing the western wall. The desks were standard desk chair combination pieces, and therefore easily able to reconfigure into groups or discussion-favorable seating arrangements.

Finishes. The ceiling was finished with white 2 feet by 2 feet ACT, most of which very clean and in good condition with little to no signs of moisture damage or tears. All four walls were CMU that had been painted off-white and were overall in good condition, with the exception of the west wall being very dirty with scuffs and stains. The floor was graveled epoxy with white, grey, and black flecks. The floor was in very good condition with no visible signs of wear.



Figures 32 and 33: Seating types in I.G. Greer classroom.

Seating and occupant density. The room has a listed capacity of 40 occupants, and the researcher found this number to correlate with the 40 desks in the room at the time of the study. With the measured area of 704 square feet, this equates to approximately 17 square feet of space per occupant, a negative 5.71% difference from the recommended area.

The seating in the room consisted of two desk-chair combination types. One was that seen in Figure 32, with a yellow plastic seat, black metal frame, and wooden laminate desktop. The other was the style seen in Figure 33, with a green hard plastic chair, metal frame, and grey plastic composite desk. There were approximately half of each type, and all of which were in very good condition with little to no signs of wear.

Natural lighting strategies. The room had four large window combinations on the southern wall. Each of which consisted of a fixed window and an awning window in the lower section, and measured 5 feet wide by 6 feet 8 inches in height. In total, there were approximately 133 square feet of glazing on the southern wall, and a calculated WFR of 18.89%. The windows faced Rivers Street and a green space on campus, with no close obstructions.

Artificial lighting strategies. The lights in the classroom consisted of six T8 troffers with florescent bulbs. A switch on the northern wall controlled the fixtures, directly beside the main entrance of the classroom, and all fixtures appeared to be in working condition.

Ingress/Egress. The room had one 3 feet wide door, totaling three feet of egress.

Other furniture, fixtures, and equipment. The room possessed a desk at the front of the classroom, as well as the standard technology package (smart podium, projector, and screen). The room did not have occupant control over thermal comfort, but appeared to have registers to access the building’s central heating system. There was a window air conditioning unit placed in one of the windows at the time of the study. There were also several outdated radiant heaters located on the southern wall. It is unknown as to whether or not these heaters are operable or used during cold months.

Unique qualities and other observations. Although it did not have any major defining features, the classroom is the only one observed in this study that possessed epoxy flooring. It is also the only room that has radiant heaters in the space.

Daylighting Results. The classroom meets LEED requirements in four of the six recoded data collection points as shown in Table 6.

Table 6 <i>Daylighting Measurements in I.G. Greer Room 219</i>			
10 feet increments in this direction			
10 feet increments in this direction	279 fc	3995 fc - HIGH	2350 fc - HIGH
	63 fc	75 fc	70 fc
			Door location (as seen from Figure 31)

Katherine Harper Hall Room 17

Built in 1961 and partially renovated in 1992, Katherine Harper Hall houses the Department of Sustainable Technology and the Built Environment as well as the Department of Applied Design and part of the Department of Art. Many of the rooms are used as applied education space for topics such as furniture design and photovoltaic technology. Although lectures are held in many of these shop and laboratory-style rooms, they would not be appropriate for the purpose of this study. Notably, only three of the rooms in Katherine Harper are coded 110.

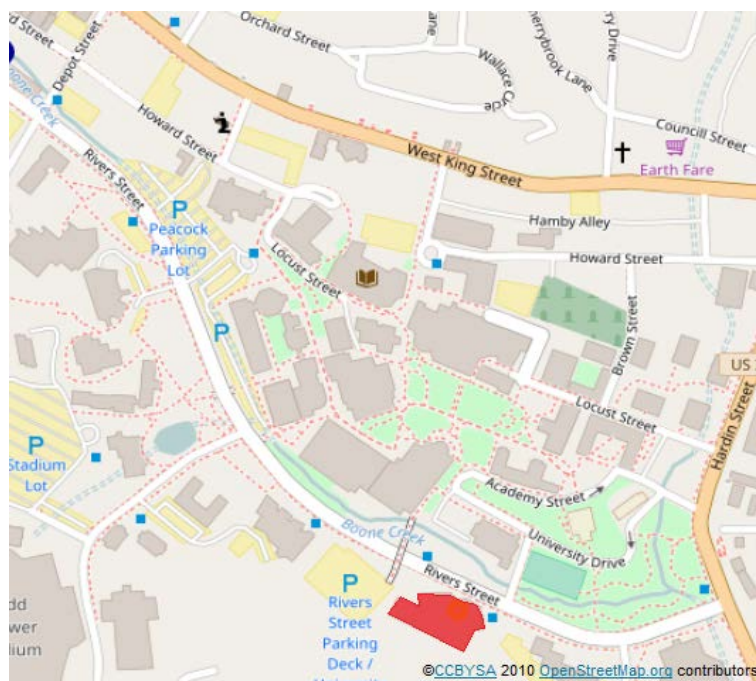


Figure 34: A campus map with the location of Katherine Harper Hall shaded in the lower middle segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 35: Panorama image from main entrance of Room 11 in Katherine Harper Hall.

Observational Features. Katherine Harper Room 11 was one of the more generic classrooms observed in this study. It seems to fit within the same group of older classrooms that are outdated in design and furniture, as well as technological advances such as access to daylight, occupant temperature control, and smart lighting systems. The lighting was harsh, but this is very common for commercial spaces such as classrooms and offices. Overall, the room was clean and well maintained. There were a few scuffs and scratches on the walls, but nothing that could harm or significantly distract occupants. The room is interior and sits on the lower level of the building.

Layout and configuration of room. The room is oriented east to west, with all of the tables and chairs facing the southern wall. The desks were aligned in two columns and five long rows, equally spaced, and justified against the eastern wall. Although the seats were close in the current table configuration, there was quite a bit of space left on the perimeter of the room for a different, more spread out configuration. Room 11 is consistently booked for this reason, as it is the only coded 110 classroom in the building that is sized for the average Appalachian State University class size.

Finishes. The design of the room was somewhat outdated, with white VCT laminate flooring, tan CMU walls, and a white ACT ceiling. All finishes were in decent condition. No

visible stains or water damage on ACT. Some scuffs and scratches on walls. Floor was clean and well maintained with little to no deterioration.

Seating and occupant density. The room was recorded as containing 40 seats, and the researcher found this to be accurate. With an assignable square footage of 1068 sq. ft., this room offers well over the recommended square feet per station, at 26 sq. ft. per occupant.

The seating consisted of long (18 inch by 4 feet) wood laminate tables with brown metal legs. The standard tables were in good condition and were a few years old. The modern ergonomic chairs had a metal frame and cushioned seat, with a sleek design (see Figure 36). Overall, the seating allows for great adaptability to the conditions in the classroom and can be moved around easily.



Figure 36: Seating in Katherine Harper Hall Room 11.

Natural lighting strategies. The room does not contain any windows or alternate daylighting technology.

Artificial lighting strategies. The room contained sixteen 2 feet by 4 feet troffers with four T8 fluorescent bulbs. The lighting is made of four N-S rows of four lights each. The lights are cool in temperature and the room is adequately lit for classroom activities.

Ingress/Egress. The room contains two doors to exit hallways. One is a 6'-0" wooden panel double door with a deadbolt lock, and the other is a single 3'-0" standard commercial wooden panel door. This accounts to 9 feet of egress for the classroom. The room also contains two closet spaces currently used for storage.

Other furniture, fixtures, and equipment. As is common with most Appalachian State University classrooms (as observed by this study), the occupant does not have control over the thermal comfort of the room. The room does not appear to have a separate air conditioning unit, and is most likely run on the same HVAC system as the rest of the building, meaning the room has no access to cool air in the summer. The room has no active ventilation system, or ventilation routed to the exterior of the building.

The room also contained two white boards, a smart podium, a projector and screen, and a sink on the Western wall. The sink may have been left over when the room was renovated. The room also contains storage closets (as mentioned previously) and may have been used as a laboratory space before the renovation.

Unique qualities and other observations. The sink was the only feature of the room that did not appear in any other classroom on campus. The walls appear to be painted a darker tan than most of the classrooms as well.

Daylighting Results. Due to the absence of windows in the classroom, there are no results for this section of the study.

L.S. Dougherty Hall Room 105

Another building scheduled for demolition, L.S. Dougherty was constructed in 1962 and has not undergone an official renovation since. Various furniture and fixtures have been replaced, but the structure remains essentially the same as the day it was built. A smaller building,

the structure is around 20,000 square feet on two floors. It houses the Department of Nutrition and Health Care Management and contains only three coded 110 classrooms, with the rest being kitchen and office spaces.

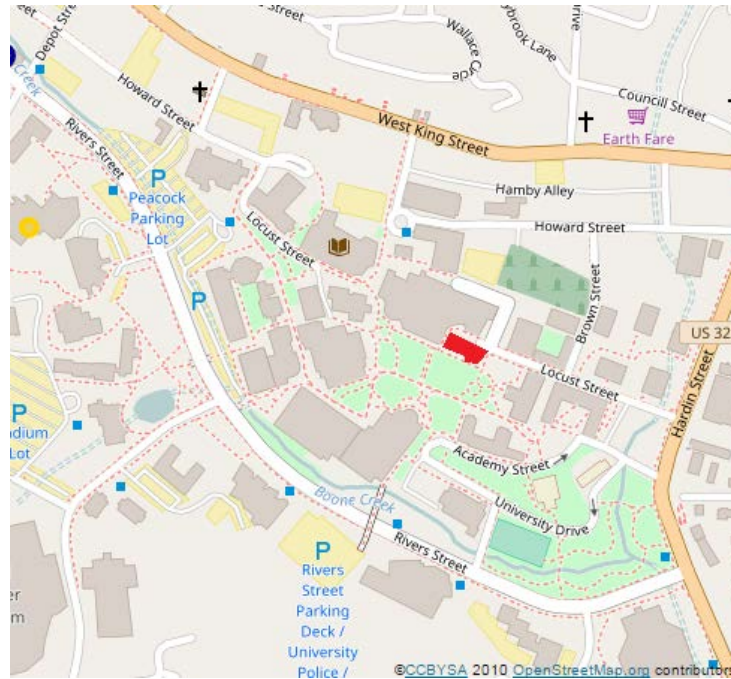


Figure 37: A campus map with the location of L.S. Dougherty shaded in the middle segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 38: Panorama image from main entrance of Room 105 in L.S. Dougherty.

Observational Features. Although it fits into the “standard’ classroom typology as defined by the findings in this study, this classroom was in great condition overall. The furniture was new and modern, the lighting fixtures have been replaced, and the finishes were clean and

well maintained. Although it is located on the north side of the building, the amount of windows on the exterior northern wall allow for daylight to penetrate the entirety of the room on sunny days. The room is also located on the lower level, below ground and with a retaining wall directly in front of the windows.

Layout and configuration of room. The room measures approximately 30 feet long by 24 feet wide, with the longitudinal axis running from east to west. This totals 720 square feet of area, and with 10 feet ceilings, 7,200 cubic feet of volume. The dimensional ratio of the classroom is 1.25, a 22.74% deviation from the golden ratio.

The desks were arranged in rows of two with an aisle down the center, all of which facing the eastern wall of the room. This configuration is ideal for lecture, but not for facilitating group discussion.

Finishes. The ceiling of the room appeared to be stucco over gypsum wall board that has been painted off white. The ceiling was in good condition with little to no signs of wear or moisture damage. Two of the walls were CMU block and two were gypsum wall board, all of which were painted the same shade of off-white. The walls were all in very good condition, with only minor scuffs. The floor was finished with a green-grey short length carpet in very good condition with a simple geometric pattern.

Seating and occupant density. The room has a maximum capacity listed as 43 occupants and the researcher counted 47 seats in the classroom at the time of the study. The measured number of seats allows for 15 square feet of space per occupant, a negative 18.18% difference from the recommended space of 18 square feet per occupant in a classroom setting.

Both the desks and chairs in the classroom at the time of the study were new and in excellent condition. The desks were long and narrow, measuring approximately 2 feet wide by 8 feet long. The frames were black metal and the tops were wood laminate. The seats, as shown in Figure 39, were blue hard plastic with a metal black frame and an ergonomic design.



Figure 39: Seating in L.S. Dougherty classroom.

Natural lighting strategies. The room has a large window configuration, consisting of hopper and fixed windows. There were eight separate sections, measuring approximately 3 feet in width and 6 feet, 6 inches in height. This is a total area of 156 square feet of glazing and equates to a WFR of 21.67%. The view from the windows was the retaining wall as previously mentioned, and a pathway that runs beside the Plemmons Student Union.

Artificial lighting strategies. The lighting system in the room consisted of three rows of six 2-lamp fluorescent fixtures, 18 total. All were working properly and were operated by two switches on the wall by the main entrance to control the number of fixtures on at one time.

Ingress/Egress. The room is accessed by one, 3 feet wide door on the south wall from a main hallway within the building, totaling 3 feet of egress.

Other furniture, fixtures, and equipment. The room did not have occupant access to thermal comfort, other than window operation during warmer months. There appeared to be registers in the ceiling with access to the building’s central heating system. There was no separate window unit for air conditioning.

The room also had the standard technology package as previously mentioned throughout this study that consisted of a smart podium, projector, and screen.

Unique qualities and other observations. While the room was not overtly unique, the overall quality of the furniture and finishes was unlike those found in classrooms located in buildings of a similar age as L.S. Dougherty, especially not in buildings that are scheduled for demolition on campus.

Daylighting Results. The classroom meets LEED requirements in all six data collection points as shown in Table 7.

Table 7 <i>Daylighting Measurements in L.S. Dougherty Room 105</i>			
	10 feet increments in this direction		
10 feet increments in this direction	77 fc	74 fc	99 fc
	25 fc	28 fc	30 fc
			Door location (as seen from Figure 38)

Living Learning Academic Center (L.L.A.) Room 223

One of the newest buildings examined in this study, the Living Learning Academic Center was constructed in 2003 and serves as the central housing and educational facility for students in the Watauga Global Community program. It also contains the Center for Appalachian Studies as well as the Department of Interdisciplinary Studies. As a result of its use, the building contains primarily student housing, office space, and research facilities, with only

four coded 110 classrooms. The most unique feature of the building is certainly the mixed-use aspect, as it is only one of two buildings (the other being Appalachian Hall) on campus holding this designation.



Figure 40: A campus map with the location of the LLA shaded in the middle-left segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 41: Panorama image from main entrance of Room 223 in the LLA

Observational Features. Another classroom that can fit into the “standard” classroom typology as defined by the results of this study, Room 223 in the Living Learning Academic Center was overall in good condition with simple furniture and finishes. Located on the second

floor and on the southern side of the building, this classroom is primarily used as lecture space for the Interdisciplinary Studies Program and Sustainable Development Department.

Layout and configuration of room. The room measures 32 feet long by 24 feet wide, with the longitudinal axis running from north to south. This was one of the few classrooms where the seating was oriented toward one of the short walls. The measured area totals 768 square feet, and with 9 feet ceilings, 6,912 cubic feet of volume. The dimensional ratio equals 1.33, an approximately 17.8% deviation from the golden ratio.

The desks were arranged somewhat randomly, with three rows facing the north wall, and tables flanking each side with seats facing the center of the room. There was also an assortment of desks along the south wall of the room with extra chairs placed throughout the room. Although messy, the current configuration allows for different types of class structures.

Finishes. The ceiling in the room was finished with both gypsum wall board and ACT, with a tray inset that utilized indirect lighting. All sections of the ceiling were in very good condition with little to no signs of wear or moisture damage. The walls were gypsum wall board painted off-white in good condition with visible scuffmarks along the bottom third. The floor was off-white VCT and in very good condition with little to no signs of damage or wear.

Seating and occupant density. The listed capacity of the classroom was 34 occupants, and the researcher found this to be accurate at the time of observation. This number does not include the various extra chairs and desks that were stacked in the back of the classroom and appear to not be used during regular class sessions. With this number of seating stations and the measured area of the classroom, this allows for 22 square feet of space per occupant. This is more than the recommended value, with a positive difference of 20%.

All of the seats in the room at the time of the study were the same design as the one shown in Figure 42, with dark green cushion and upholstery and a black metal frame. All seats appeared to be in very good condition, with little to no signs of wear. The desks were long and narrow with a black metal frame and white laminate top, and overall in very good condition.



Figure 42: Chair type in L.L.A. classroom.

Natural lighting strategies. The room had two sliding windows, measuring 4 feet by 4 feet and one fixed window measuring 2 feet wide by 4 feet in height. This totals 40 square feet of glazing, and a WFR of 5.2%. The windows faced toward a wooded section of campus, with mostly trees visible in the view.

Artificial lighting strategies. The room had three rows of four suspended LED fixtures each, 12 in total. The long fixtures hung in the tray of the ceiling and had both direct and indirect lighting. They were controlled by three switches beside the entrance that could alter the number of fixtures operating at a given time. All were in working condition at the time of observation.

Ingress/Egress. The room had one, 3 feet wide door totaling 3 feet of egress into a main hallway on the second floor of the building.

Other furniture, fixtures, and equipment. The room had the standard technology package as defined by the results of this study. There were whiteboards and corkboards present on two walls of the room that were in very good condition.

Unique qualities and other observations. The room did not have any defining features that would set it apart from the other rooms observed in the study.

Daylighting Results. The classroom meets LEED requirements at one of the seven recorded data points as shown in Table 8.

Table 8 <i>Daylighting Measurements in L.L.A. Room 223</i>			
10 feet increments in this direction			
10 feet increments in this direction	16.16	No tables	4.83 - LOW
	1.71 fc - LOW	1.55 fc - LOW	1.58 fc - LOW
	No tables	1.34 fc - LOW	1.74 fc - LOW
	Podium Location		Door location (as seen from Figure 41)

Peacock Hall Room 1018

Previously known as Thelma C. Raley Hall, Peacock Hall is the third largest academic building on campus, with over 130,000 gross square feet (gsf) of area on four floors. The structure was built in 1990 and has not undergone a renovation, but is scheduled to receive an addition in the 2020 Campus Master Plan. The building contains the College of Business and its various departments: Department of Accounting, Department of Computer Information Systems and Supply Chain Management, Department of Economics, Department of Finance, Banking, and Insurance, Department of Management, Department of Marketing, and the university Information Technology Services. The building contains by far the most coded 110 classrooms, at 38, with the average capacity of the rooms being 44 and the median being 35.

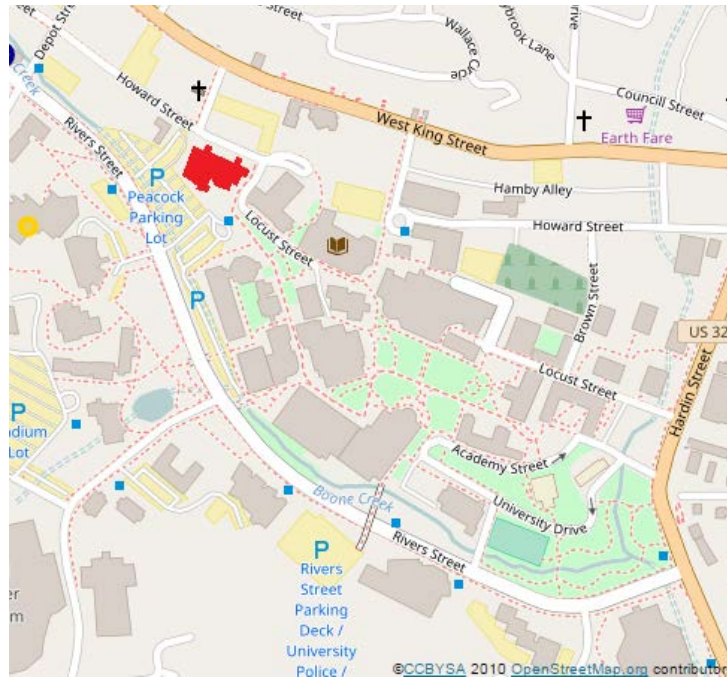


Figure 43: A campus map with the location of Peacock Hall shaded in the top-left segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 44: Panorama image from main entrance of Room 1018 in Peacock Hall.

Observational Features. Located on the first floor in the interior of Peacock Hall and with no exterior walls, Room 1018 was in overall good condition at the time of observation. The room serves as a lecture space for the Department of Management.

Layout and configuration of room. The room measures 39 feet long by 28 feet wide, with the longitudinal axis running perpendicular to the seating rows, as seen in Figure 44. The ceiling height varies due to the sloped floor, but has a minimum of 9 feet along the back wall of

the room. The total area is 1,092 square feet, with a dimensional ratio of 1.39, a 14.09% deviation from the golden ratio.

The desks were arranged in curved rows and were semi-permanent, without the capability of reconfiguration. This is ideal for lecture halls of this style, and does not facilitate group discussion.

Finishes. The ceiling consisted of both ACT and gypsum wall board painted white. The ACT was in good condition, with some stains and moisture damage, while the gypsum wall board was clean and well maintained. All four walls were white painted gypsum wall board, in very good condition. The floor was finished with a multicolored brown carpet, which was in very good condition with little to no signs of wear.

Seating and occupant density. The listed capacity of the room was 56 occupants, and the researcher found this to be consistent with the number of seating stations at the time of observation. With the measured area of 1,092 square feet, this equates to 19 square feet of space per occupant. This leads to a positive percent difference of around 5.4.



Figure 45: Seating types in Peacock Hall classroom.

The seating in the room was comprised of desk chair combinations similar to those found in Garwood Hall. The chairs were attached to the desks and swing outward to be accessible to occupants. The desks and chairs were constructed of steel and grey plastic, with red leather upholstery as shown in Figure 45. Most were in very good condition, but there were two missing chairs in the back row, which had been replaced with cushioned wooden desk chairs.

Natural lighting strategies. The room does not contain any windows or alternate daylighting technology.

Artificial lighting strategies. The lighting in the room consisted of what appeared to be flush-mounted LED parabolic troffers, organized in five rows of four each. All of which were in working condition and were operated by switches by both exits.

Ingress/Egress. The room had one main entry on the top level with one 3 feet wide metal door, and another at the bottom of the room, totaling 6 feet of egress.

Other furniture, fixtures, and equipment. The room had registers in the ceiling to provide access to the building's central HVAC system, with no separate occupant controls or occupant access to external ventilation. The room also had the standard technology package of a projector, screen, and podium. In the back of the room, there were acoustic panels mounted on the wall to help with sound distribution.

Unique qualities and other observations. This was the only room observed in the study with a stepped floor, not considering the slightly sloped floor found in Turchin Center Room 1102.

Daylighting Results. Due to the absence of windows in the classroom, there are no results for this section of the study.

Rankin West Room 157

Rankin West is technically a section of the entire structure that is Rankin Hall. The oldest segment of the structure, Rankin West was constructed in 1970, before the additions of Rankin North and Rankin East were built in the early 2000s. It was officially renovated in 2006, costing \$2.6 million. Rankin West is unique in the fact that it is the only section of the structure that contains any coded 110 rooms. Rankin East and Rankin North consist primarily of coded 200 rooms (research and laboratory spaces) and were therefore not appropriate to be included in the sample of this study. The structure contains nine coded 110 classrooms, with a median occupancy of 49.

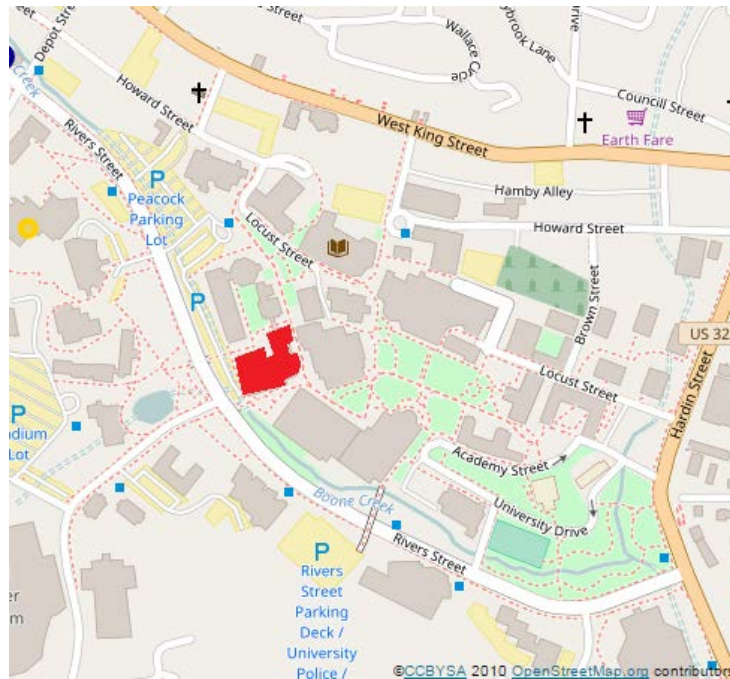


Figure 46: A campus map with the location of Rankin shaded in the middle-left segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 47: Panorama image from main entrance of Room 157 in Rankin.

Observational Features. Located on the second floor on the southeastern side of Rankin West, this classroom was overall in very good condition at the time of observation. It is used primarily as a lecture space for the Biology Department.

Layout and configuration of room. The room measures 28 feet long by 22 feet wide, totaling 616 square feet of space. The ceilings are 8 feet high, equating to 4,928 cubic feet of volume. The dimensional ratio of the room is approximately 1.27, a 21.51% deviation from the golden ratio. The longitudinal axis of the room runs east to west.

The tables in the room were arranged in three rows of four desks apiece, all of which were facing the northeast wall.

Finishes. The ceiling in the room was white ACT in very good condition with little to no signs of moisture damage or wear. The floor was 1 foot by 1 foot white VCT, also in very good condition with little to no signs of damage or wear. The walls were all white CMU block with a light grey trim. Aside from scuffs here and there, the walls were also in very good condition.



Figure 48: Seating type in Rankin Hall West classroom.

Seating and occupant density. The capacity of the room was listed as 18, and the researcher counted 24 chairs in the room at the time of the study. With the measured number of seats, this allows for 25 square feet per occupant, a positive 32.56% difference from the recommended value.

The seats in the room were grey plastic with a black frame and in very good condition with little to no signs of wear. The desks were standard length with black metal frames and a grey laminate top, also in very good condition.

Natural lighting strategies. The room had four very skinny windows that measured approximately 1 foot in width and 4 feet 9 inches in height. The windows were each in two segments, with the top three quarters being inoperable fixed windows and the bottom 1 foot by 1 foot sections being awning windows. This equates to 19 square feet of glazing and a WFR of 3.08%. From the windows, an observer can see the roof of the first level of Rankin West below, and Varsity Gymnasium beyond.

Artificial lighting strategies. The room had nine 2 feet by 2 feet fluorescent troffers, spaced evenly throughout the room in three rows of three. One of the lights had a bulb out, but the rest were working properly at the time of observation. Light fixtures are operated by two switches adjacent to the main entrance that could alter the amount that came on at any given time.

Ingress/Egress. The room had one, 3 feet wide door that exited to a main hallway in the building, totaling three feet of egress.

Other furniture, fixtures, and equipment. There were registers present in the ceiling of the room to give access to the building’s central HVAC system. Aside from the four small windows, there was no mechanical occupant control over thermal conditions. There were chalkboards present on two walls, as well as the standard technology package.

Unique qualities and other observations. The skinny windows are the only prominent feature of the classroom.

Daylighting Results. The classroom meets LEED requirements in four of the six recorded data points as shown in Table 9.

Table 9 <i>Daylighting Measurements in Rankin West Room 157</i>		
10 feet increments in this direction	10 feet increments in this direction	
	1437 fc – HIGH	45.4 fc
	36.9 fc	45 fc
	8.3 fc – LOW	10.8 fc
	Door location (as seen from Figure 47)	

Reich College of Education Room 237

Observational Features. Located on the second floor of the newly constructed Reich College of Education, this room is entirely interior and in very good condition overall.

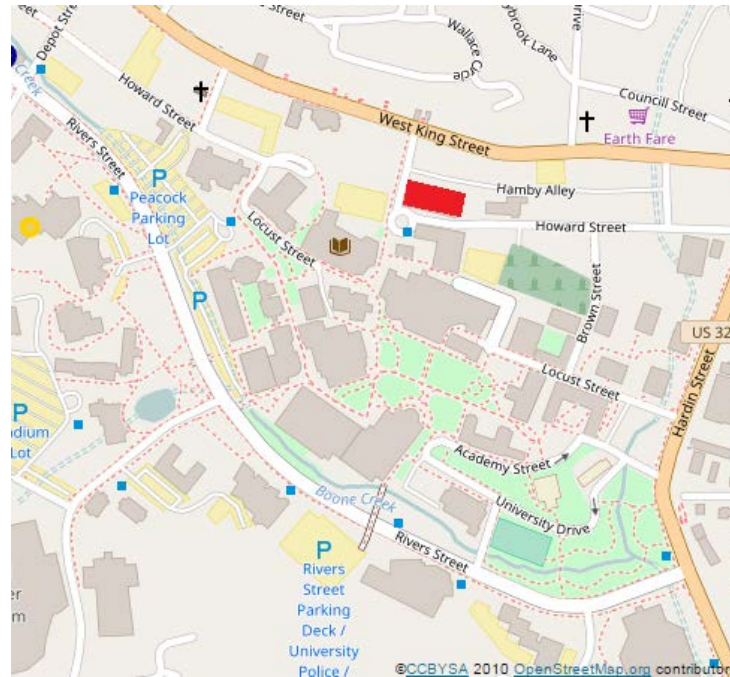


Figure 49: A campus map with the location of the Reich College of Education shaded in the top-middle segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 50: Panorama image from main entrance of Room 237 in the Reich College of Education.

Layout and configuration of room. The room measures 24 feet wide by 31 feet long, with the longitudinal axis running parallel to the camera view in Figure 50. These dimensions

equate to an area of 744 square feet and a dimensional ratio of 1.29 (a 20.27% deviation from the golden ratio).

The desks were arranged in somewhat of a U shape, with several small grouped tables and a presumed orientation toward the wall with the white boards. This is unique in that with the current configuration, nearly all seated occupants could view two walls as well as be in groups for discussion.

Finishes. The floor was an off-white epoxy resin over concrete in very good condition. The walls of the room were gypsum wall board, three of which being white and one accent wall being painted a grey-green. The walls had visible scuffs, but were overall in good quality. The ceiling was white ACT with no visible signs of damage or moisture.



Figure 51: Seating type in Reich College of Education classroom.

Seating and occupant density. The capacity of the room is listed as 36, while the researcher counted only 26 seats at the time of observation. With the listed capacity and measured room area, each occupant would have 20 square feet per occupant, but with the

current configuration each occupant would have 28 square feet of space. This measured value is a positive difference of 43.48%, much more than the recommended space.

Natural lighting strategies. The room does not contain any windows or alternate daylighting technology.

Artificial lighting strategies. The room is illuminated with 9 LED T8 troffers, all of which were in working condition at the time of observation. The lights were controlled by occupant sensors located next to the entrance, as well could be operated by manual switches.

Ingress/Egress. The room had one point of access, which measured 3 feet in width, totaling 3 feet of egress.

Other furniture, fixtures, and equipment. Aside from the standard technology package, the room did not have any additional furniture or equipment worth noting. The occupant did not have control over the thermal comfort of the room, but there were registers that allowed access to the building's central HVAC system.

Unique qualities and other observations. The room did not have any unique qualities that are worth noting to the researcher.

Daylighting Results. Due to the absence of windows in the classroom, there are no results for this section of the study.

Sanford Hall Room 208

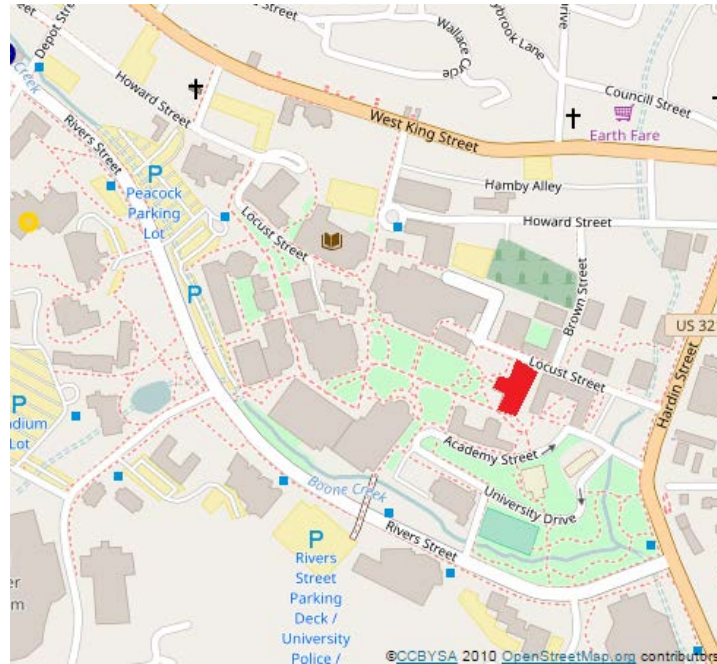


Figure 52: A campus map with the location of Sanford Hall shaded in the middle-right segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 53: Panorama image from main entrance of Room 208 in Sanford Hall.

Observational Features. Located on the second floor of Sanford Hall, this classroom has three interior walls and one south-facing exterior wall. The room was overall in good condition, with some finishes in need of repair or replacement.

Layout and configuration of room. The room measures 22 feet wide by 26 feet long, totaling 572 square feet of space. With 8 feet high ceilings, the room has 4,576 cubic feet of

volume. The longitudinal axis runs north to south, and the dimensional ratio equals approximately 1.18, or 27.07% deviation from the golden ratio.

The desks were arranged in an open U shape, with the opening facing the westerly wall. This configuration and the type of seating allows for great adaptability in type of class session.

Finishes. The ceilings of the classroom were white ACT in poor to fair condition, with sagging sections, moisture stains, and some with extensive damage. The floors were 1 foot by 1 foot VCT, with grey and multicolored specks, overall in very good condition with no peeling sections or signs of wear. The walls were all CMU painted an off-white with grey trim and overall in good conditions. Scuffmarks were present, but no extensive damage or wear.

Seating and occupant density. The listed capacity of the room was 32 occupants, and the researcher counted 26 desks at the time of observation. With the measured capacity, this equates to 22 square feet of area per occupant, a positive 20% difference from the recommended value of 18 square feet of space. Had the room contained the listed capacity of 32 desks, this value would drop to 17 square feet per occupant.



Figure 54: *Seating type and arrangement in Sanford Hall classroom.*

The seating consisted of standard desk-chair combination pieces, all of which were constructed of a metal frame and a light brown plastic composite desktop with a blue plastic seat

(see Figure 54). All pieces of furniture appeared to be in very good condition, with little to no signs of wear.

Natural lighting strategies. The room contained five double hung windows that measured 2 feet 6 inches wide by 5 feet in height. This is a total glazing area of 62 feet 6 inches and a WFR of 10.84%. All windows appeared to be operating correctly at the time of observation. The view was highly obstructed by trees along the south side of the building.

Artificial lighting strategies. The room contained 12 T8 troffers with fluorescent bulbs, which were arranged in three rows of four. All lights were working properly at the time of observation.

Ingress/Egress. The room had one access point, which was a door 3 feet in width, totaling 3 feet of egress.

Other furniture, fixtures, and equipment. The room contained the standard technology package and had no additional furniture worth noting. There were registers presumably supplied by the building’s central heating system, and no occupant control over thermal comfort aside from the windows during warmer months.

Unique qualities and other observations. There were no unique qualities worth noting to the researcher.

Daylighting Results. The classroom meets LEED requirements in two of the four recorded data point locations as shown in Table 10.

Table 10 <i>Daylighting Measurements in Sanford Hall Room 208</i>	
10 feet increments in this direction	10 feet increments in this direction
	15 fc 38 fc
	5 fc – LOW 5 fc - LOW
	Door location (as seen from Figure 53)

Smith-Wright Hall Room 200

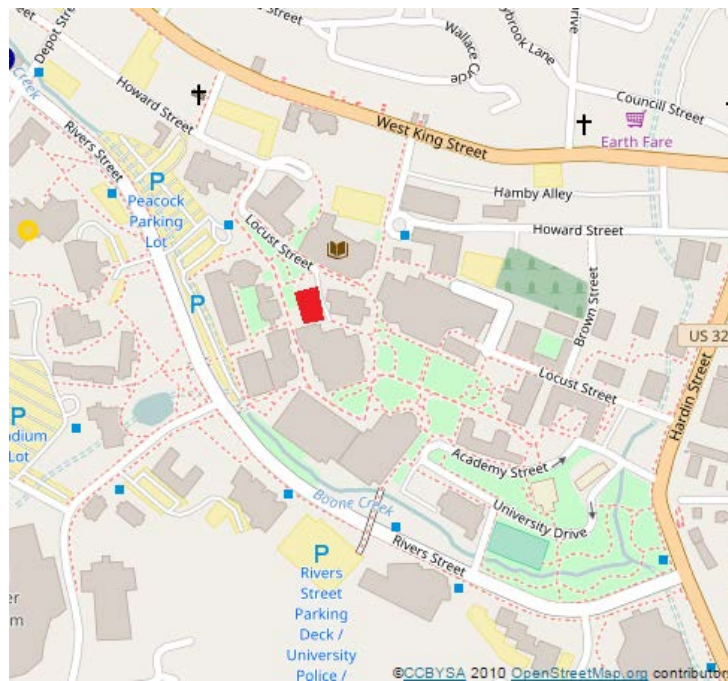


Figure 55: A campus map with the location Smith-Wright Hall shaded in the middle segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 56: Panorama shot from main entrance of Room 200 in Smith-Wright Hall.

Observational Features. Located on the second floor of Smith-Wright Hall, room 200 was bright and open primarily due to it having two exterior walls lined with large windows on the south and east sides of the classroom. The room was overall in good quality and has been well maintained since the building's renovation in 2006. It serves as a lecture space for the Department of Psychology.

Layout and configuration of room. The room measures 37 feet long by 27 feet wide, with the longitudinal axis running approximately north to south. It totals 999 square feet in area and has a dimensional ratio of 1.37. This is equal to a 15.33% deviation from the golden ratio.

The desks were arranged in long columns, all facing the western window. The desks would allow for great adaptability if there were more space between the columns.

Finishes. The ceiling in the room was white ACT in excellent condition with no signs of moisture or damage. The floor was light grey VCT, overall in very condition with little to no signs of wear or damage. Three of the walls were CMU block and one interior wall was gypsum wall board. The two exterior walls were painted a dark teal and the two interior walls were painted white. All walls were in very good condition with little to no signs of wear or damage.



Figure 57: Seating type in Smith-Wright Hall classroom.

Seating and occupant density. The room occupancy was listed as 50 occupants, while the researcher counted 52 desks present at the time of the study. With the current number of seats, this equates to 19 square feet of space per occupant, a positive 5.41% difference from the recommended number.

The seating in the room consisted of modern desk-chair combination pieces. The frames were dark red painted metal and the seats themselves were dark grey plastic. The tops of the desks appeared to be constructed of solid wood or wood laminate over a particle composite

material. All of the seating was in excellent condition, except for one desk that had deteriorated and had student drawings on the bare wood.

Natural lighting strategies. The room had a total of 12 large double hung windows, each measuring 1 foot 9 inches wide and 6 feet 4 inches tall. This equates to 133 square feet of glazing and a WFR of 13.31%. The windows viewed a green part of campus and walkways between buildings, with no obstructions.

Artificial lighting strategies. The artificial lighting in the room was comprised of 12 T8 troffers with fluorescent bulbs, all of which were in working condition at the time of observation. The lights were controlled with three switches beside the main entrance so that a combination of lights could be controlled depending on the situation.

Ingress/Egress. The room had one 3 feet wide door that exited to a main hallway, totaling three feet of egress.

Other furniture, fixtures, and equipment. The room had ceiling registers to access the building's central heating system, but aside from windows did not have occupant control over thermal comfort or external ventilation. The room was also equipped with the standard technology package.

Unique qualities and other observations. The most defining quality of the room was the color on the two exterior walls. It was also the only room observed in the study that had two exterior walls, which both had windows.

Daylighting Results. The classroom meets LEED requirements in all six of the recorded data point locations as shown in Table 11.

Table 11 <i>Daylighting Measurements in Smith-Wright Hall Room 200</i>			
10 feet increments in this direction			
10 feet increments in this direction	174 fc	148.8 fc	103 fc
	304 fc	96 fc	54 fc
			Door location (as seen from Figure 56)

Turchin Center for the Visual Arts Room 1102

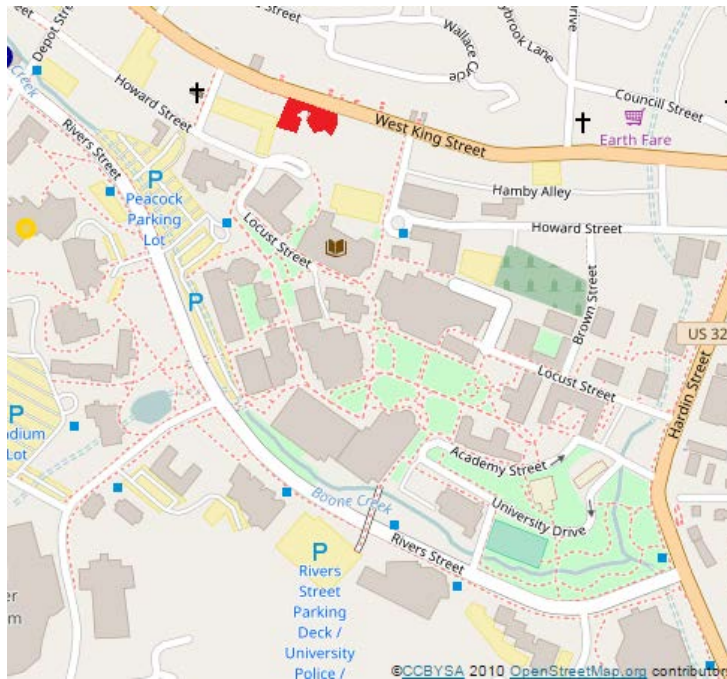


Figure 58: A campus map with the location of the Turchin Center shaded in the top-middle segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 59: Panorama image from main entrance of Room 1102 in the Turchin Center.

Observational Features. Similar to a small auditorium, this classroom is the only one of its kind in the Turchin Center building. In excellent condition overall, the room is located on the lower level of the building with two exterior walls and two interior walls. It is used primarily as a lecture space for the Art Department and as a seminar space for the Turchin Center for the Visual Arts.

Layout and configuration of room. The room measures approximately 38 feet long by 35 feet wide, totaling an area of 1,330 square feet. The dimensional ratio of these measurements is 1.09, a 32.63% deviation from the golden ratio. The longitudinal axis of the room runs perpendicular to the camera angle as seen in Figure 59.

The seating in the room was comprised of fixed auditorium seating and allows for lectures or seminars, but does not suit discussion-based classes.

Finishes. The ceiling in the room consisted of both white ACT and white gypsum wall board, all of which were in excellent condition. The floor was multicolored grey carpet in good condition with some stains, but no visible rips or tears. The walls were gypsum wall board, three of which being light grey and one being blue. All of the walls were in excellent condition with no signs of damage or wear.



Figure 60: Seating type in Turchin Center for the Visual Arts classroom.

Seating and occupant density. The capacity of the room was listed as 80 occupants, and the researcher found the same number of seats in the classroom at the time of observation. With the measured square footage, this equates to 16 square feet of space per occupant, a negative 11.76% difference from the recommended area of 18 square feet per occupant. This could potentially be due to the room being more of an auditorium setting, where the recommended space per occupant is less than in that of a classroom.

Natural lighting strategies. The room does not contain any windows or alternate daylighting technology.

Artificial lighting strategies. The room appears to only have recessed can lighting that can be operated on a dimmer. The lights are spread in rows throughout the room, and all were in working condition at the time of observation.

Ingress/Egress. The room had two doors, one of which measured 3 feet wide, and the other being a 6 feet wide double door, totaling 15 feet of egress. The double door exited to a main hallway of the building, while the single door led directly to the exterior.

Other furniture, fixtures, and equipment. The room had registers for access to the building's HVAC system, but there was no occupant control over thermal comfort. The room possessed the standard technology package as well, and had acoustic panels mounted throughout the room to assist in sound distribution.

Unique qualities and other observations. The room was the only one in the study that more accurately could be described as an auditorium.

Daylighting Results. Due to the absence of windows in the classroom, there are no results for this section of the study.

Walker Hall Room 308

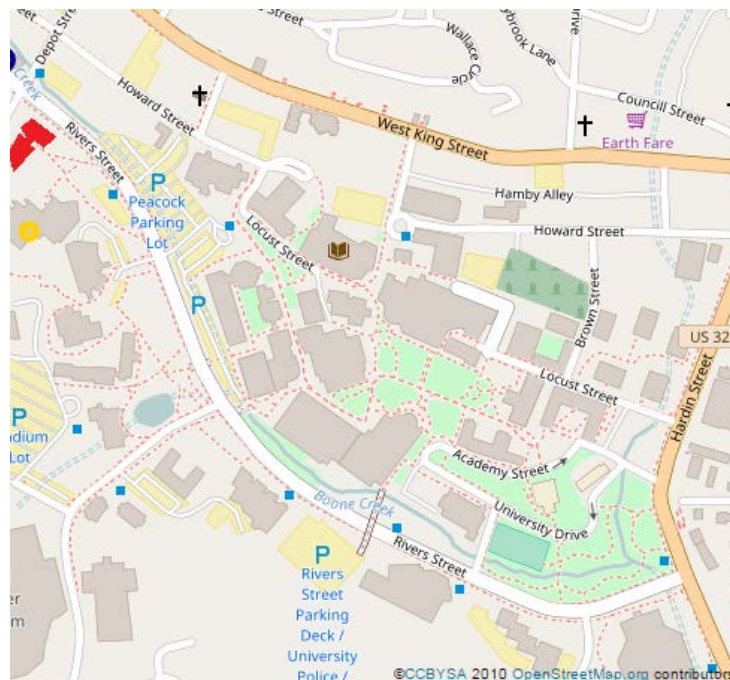


Figure 70: A campus map with the location of Walker Hall shaded in the top-left segment of the image. Adapted and slightly edited for use from Campus Maps, by Appalachian State University. Retrieved from <https://maps.appstate.edu/campus-map/13>. Copyright 2017 by Appalachian State University.



Figure 71: Panorama shot from main entrance of Room 308 in Walker Hall.

Observational Features. Room 308 in Walker Hall is located on the third floor of the building and has one exterior wall and three interior walls. The exterior wall faces southeast and allows for daylight access. The room was overall in very good condition, with standard fixtures and furniture.

Layout and configuration of room. The room measures approximately 24 feet by 21 feet with one angled wall, reducing the square footage area available in the space. It totals 505 square feet of area, with the longitudinal axis running northwest to southeast. The dimensional proportions in the room equate to a ratio of 1.14, a 29.54% deviation from the golden ratio.

The tables were arranged in four rows facing the northeast wall, with little space for reconfiguration.

Finishes. The ceiling in the room was finished with white ACT in very good condition, with little to no signs of damage or wear. The walls were painted off-white CMU block and were in good condition with a few scuffmarks. The floor was finished with a blue-grey carpet in fair condition with some stains and signs of wear.



Figure 72: Seating type in Walker Hall classroom.

Seating and occupant density. The occupancy in the room was listed as 30 occupants, and the researcher found this number to coincide with the number of seats in the room at the time of observation. This density equates to 16 square feet of space per occupant, a negative 11.76% difference from the recommended area per occupant.

The seats in the room were simple with metal frames and a black plastic seat and back. The chairs were all in very good condition, with the exception of two of a different style, which appeared old and worn. The desks were a standard length metal frame and laminated top, all with no signs of wear or damage.

Natural lighting strategies. The room had two double hung windows on the southeast wall, each of which measured 2 feet 9 inches wide by 5 feet 4 inches tall. This equates to a total of 29.33 square feet of glazing and a WFR of 5.81%. The windows faced southeast and had a wide view of campus with no obstructions.

Artificial lighting strategies. The room had six T8 troffers with fluorescent bulbs arranged in diagonal rows, all of which appeared to be working properly at the time of observation. Two switches near the main entrance operated the lights.

Ingress/Egress. The room had one egress door, which measured 3 feet in width.

Other furniture, fixtures, and equipment. The room had registers for access to the building’s central heating system, but had no separate occupant controls over thermal comfort or ventilation aside from the windows. There were chalkboards mounted on four of the five walls, as well as whiteboards on the eastern wall. The room also had the standard technology components that were present in all rooms observed in the study.

Unique qualities and other observations. The room did not have four 90 degree corners, and it had five walls instead of four.

Daylighting Results. The classroom meets LEED requirements in all six recorded data point locations as shown in Table 12 below.

Table 12 <i>Daylighting Measurements in Walker Hall Room 308</i>		
	10 feet increments in this direction	
10 feet increments in this direction	24 fc	12.44 fc
	15.03 fc	10.91 fc
		Door location (as seen from Figure 71)

CHAPTER 5: CONCLUSIONS AND DISCUSSION

Conclusions

Observational Data Analysis

Appalachian State University has a specific typology that classrooms generally fit into in regard to design. This is shown graphically in Table 13.

Table 13
Finishes by Quantity and Type

Floor Finish	
VCT	8
Carpet	10
Epoxy	1
Other	0
<hr/>	
Total	19
Ceiling Finish	
ACT	14
Combination	4
Other (stucco)	1
<hr/>	
Total	19
Wall Finish	
CMU	6
Gypsum wall board	9
Both	4
<hr/>	
Total	19

Occupant Density

In regards to occupant density, Appalachian State University nearly meets the space demand for every classroom observed in the study. Out of the 19 classrooms analyzed, only five did not currently meet the recommended guidelines for space per occupant. This is shown in Table 14.

Table 14
Classrooms Meeting Occupant Density Guidelines

Building	Met?	Percent Difference
Anne Belk	Y	38.00%
Appalachian Hall	Y	11.68%
Beasley Media Complex	Y	40.00%
Broyhill Music Center	Y	5.41%
Chapell Wilson	Y	0.00%
DD Dougherty	Y	56.00%
Edwin Duncan	Y	24.50%
Garwood Hall	N	-15.80%
IG Greer	N	-5.71%
Katherine Harper Hall	Y	36.36%
LS Dougherty	N	-18.80%
LLA	Y	20.00%
Peacock	Y	5.40%
Rankin West	Y	32.56%
Reich College of Education	Y	43.48%
Sanford Hall	Y	20.00%
Smith-Wright Hall	Y	5.41%
Turchin Center for the Visual Arts	N	-11.76%
Walker Hall	N	-11.76%

Of the values shown, the majority of the classrooms are well over the recommended space per occupant of 18 square feet. Those that fall below the guidelines usually do so by only one or two seat stations.

Daylighting Study

Of the 12 classrooms that had windows, three of the classrooms met the LEED requirements in all data points recorded in the room. Of the 67 data points collected in the study, six measurements were above the 500fc LEED maximum, 15 were below the 10fc LEED minimum, and 46 fell within those guidelines. Table 15 shows the average of all measurements taken within each classroom.

Table 15
Average of Data Collection Points by Classroom

Building	Average (fc)
Anne Belk	N/A
Appalachian Hall	1069.33
Beasley Media Complex	66.725
Broyhill Music Center	N/A
Chapell Wilson	416.5
DD Dougherty	7.33
Edwin Duncan	32.27
Garwood Hall	N/A
IG Greer	1138.667
Katherine Harper Hall	N/A
LS Dougherty	55.5
LLA	4.13
Peacock	N/A
Rankin West	263.9
Reich College of Education	N/A
Sanford Hall	15.75
Smith-Wright Hall	146.63
Turchin Center for the Visual Arts	N/A
Walker Hall	15.595

Discussion

Recommendations for Future Classroom Design

It is difficult to find an appropriate balance between energy efficiency and amount of glazing used for natural daylighting. It is commonly known that with additional glazing, there may be sacrifices to be made in the area of efficiency. With new glazing technology, it is not only possible to achieve similar energy efficiency in buildings, but it is recommended for human health. I recommend that all newly constructed classrooms on the Appalachian State University campus contain access to daylight through glazing or alternative daylighting strategies, unless light blockage is necessary for the type of instruction. This is to not only improve the health and productivity of our students, but to provide a better representation of the Strategic Plan Guidelines in our campus facilities. Out of the seven classrooms that did not have access to

daylight, five were built after 1980. One of them is LEED certified and is less than 10 years old, and not one of its classrooms has access to daylight. It is acknowledged that there are complications in design and that faculty offices may have priority over exterior walls, so this may not always be possible. It is imperative that the university acknowledges this lapse in design judgment.

For future classroom designs, priority should be placed on those that allow for natural daylighting. In terms of area of glazing, it is recommended that university classrooms have a calculated WFR of between 10% and 25% to maximize natural light as well as efficiency. The windows should have working glare reduction strategies, whether they be mechanical (drapes or dense blinds) or glazing treatments, per the LEED Building Design and Construction 8.1 Daylighting Credits.

Occupant operable windows are an issue that needs to be considered on a building-by-building basis. Many newer buildings have central HVAC systems that are properly regulated to control temperature and humidity in rooms, and the efficiency of said systems can be affected by occupant controls. Appalachian Hall exhibited a great alternative for this, with two very small awning windows that allow for supplemental ventilation in moderate seasons. University-wide HVAC systems are sometimes centrally controlled, and because of deviation between buildings, slight occupant control might be the best option to maintain efficiency.

Passive design concepts would be particularly helpful in window orientation. For older or less efficient buildings, south facing windows are a major contributor to heat gain. In summer months with no HVAC system, heat can build up in classrooms and become extremely uncomfortable. While daylighting should not be set aside, temperature moderation should definitely be considered. This heat gain can be alleviated with properly designed exterior louvered shading, to maximize thermal gain in cooler months and minimize thermal gain in

warmer months. Northern window placement is very useful for indirect lighting, and can reduce peaks in illuminance levels.

In regards to use of space, Appalachian State University does an excellent job in providing enough room for classroom occupants.

As a whole, the quality of the classrooms was shown to be good. None of the classrooms observed show signs of immediate need for replacement or repair. However, several classrooms show signs of moisture damage on the ceiling tiles, which may or may not be an area for future attention.

Suggestions for Future Research

A study of this type has many variables and therefore some opportunity for deviation. The researcher recognizes each of these and believes the study still holds value as a comprehensive holistic analysis of classrooms in which students spend each day.

One of the major complications with the study was classroom accessibility. According to specified guidelines, daylighting measurements had to be taken between 9:00 a.m. and 3:00 p.m. on clear days. Although this was adhered to, the time of day could have had an impact on the results of the study. For example, Room 223 in the L.L.A had a WFR similar to other classrooms, but the daylighting measurements recorded were much lower, to the point of it not passing LEED requirements. Because this room was accessed at 9:30 a.m., the recordings may have been skewed from the other rooms in the study because of the solar azimuth at that time of day.

Another issue to note with this type of study is the orientation of the classrooms recorded. Although most of the classrooms were on the southern side of the building out of pure chance, it would have been more comprehensive to have more than one classroom in each

building, each of which located on a different side. This would have given a more accurate representation of classrooms as a whole.

A small issue noted during data collection was that there were discrepancies between recorded room areas and data from the university classroom database and researcher-measured areas (as well as with maximum occupancy and recorded number of seats). This may be due to the “assignable square footage” of rooms in the database omitting certain areas, but it became apparent that some of the measured values were greater than the recorded area for rooms. I do not know why this occurred, or what steps the university takes when calculating room area.

In terms of daylighting, there are a number of ways that the study could have given a more holistic representative of university classrooms. As with any building, rooms are typically located on one side and therefore will vary in regards to daylight. Rooms on the southern face of buildings will most likely experience more daylight exposure than those on the north side, regardless of obstructions. In the future, it should be considered that more than one room per building should be identified and analyzed for daylighting measurements.

I began this study with the idea of expansion and future research in mind. There is the possibility of the research being expanded into different IEQ categories as primary variables, such as acoustics, indoor air quality, aesthetics, and more. The possibility of expanding the number of classrooms in the study could provide a more holistic view of classrooms on campus, adding classrooms of the same or different typologies. This could include additional classrooms of average size or those with greater occupancy, for example.

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APPENDICES

Appendix A

DATA COLLECTION FORM

IEQ Characteristics

Building: _____ Date: _____ Time of day: _____

Room Number: _____ Orientation of Building: _____ Room orientation: _____

Area (sq ft): _____ Building built (year): _____ Building renovated (year): _____

FLOOR

Type: _____ Color: _____ Comments: _____

CEILING

Type: _____ Color: _____ Comments: _____

Height (ft): _____

WALLS:

Type: _____ Color: _____ Comments: _____

SEATING:

Type: _____ Color: _____ Comments: _____

Number: gypsum wall

board _____ Quality: _____

OTHER FURNITURE

Type: _____ Color: _____ Comments: _____

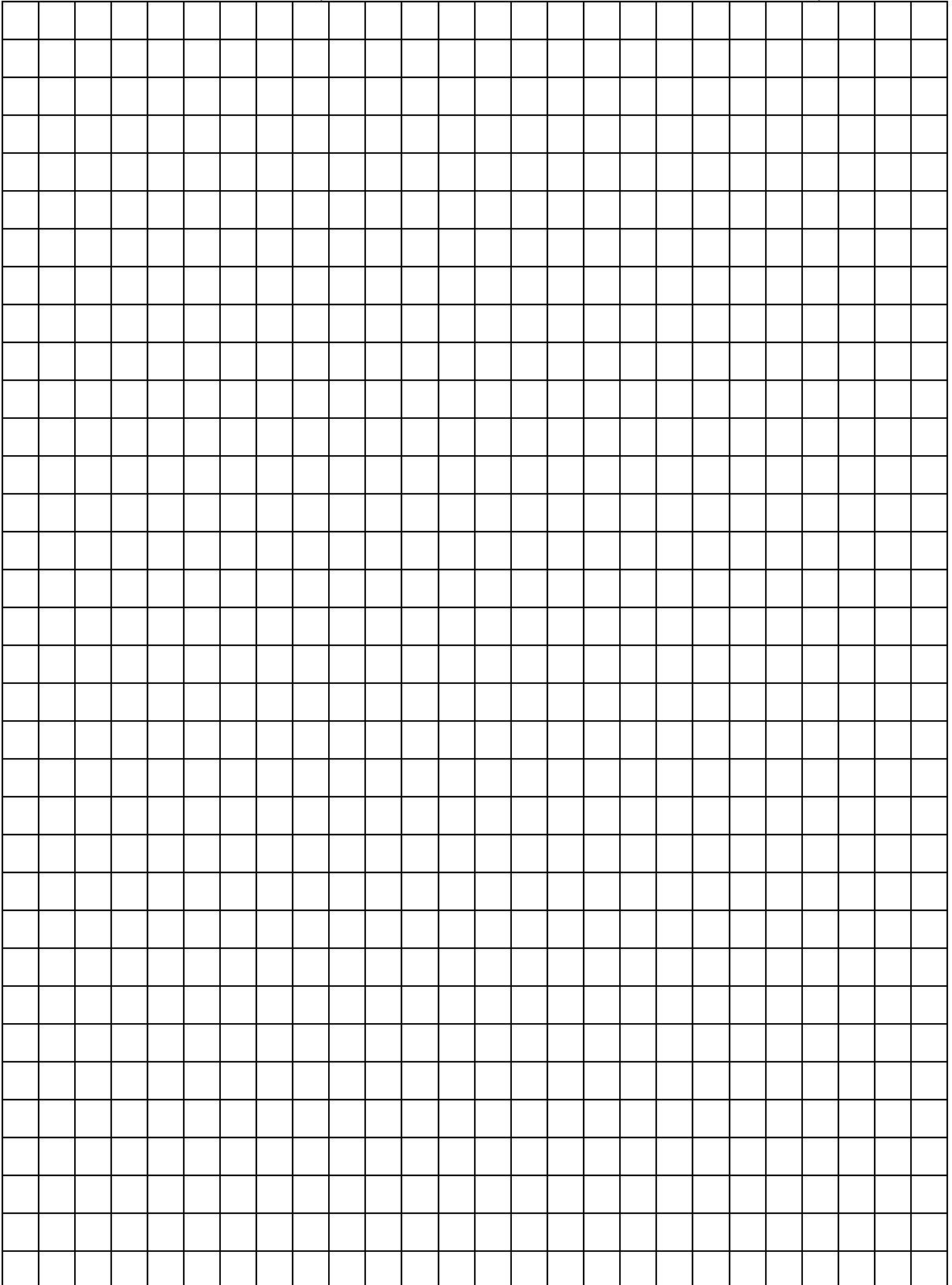
GLAZING

Type: _____ Area (sq ft): _____ Comments: _____

Calculated WFR: _____ View observations: _____

OTHER OBSERVABLE FEATURES:

DRAW ROOM FOOTPRINT (Label windows, doors, orientation, dimensions, etc)



Appendix B

Building	Room	Room_Use_ Code	Capacity	Assignable_Square_Feet	Assignable_Square_Feet_Per_Sq	Owner_Organi zation	Partition	TSS_T ech	built
Anne Belk Hall	BH 251	110	30	762	25	HIS	HIS	Yes	1968
Appalachian Hall	AH 161	110	20	405	20	HON	HON	Yes	2013
Beasley Media Complex	BMC 224	110	35	820	23	COM	COM	Yes	1945
Belk Library	BLC 114	110	125	1908	15	COLLEGE OF ARTS	CAS	Yes	2005
Broyhill Music Center	BM 206	110	33	588	17	MUS	MUS	Yes	1983
Chapell Wilson Hall	CW 111	110	30	634	21	THR	THR	Yes	1938
DD Dougherty Hall	DD 237	110	28	1474	52	MSL	MSL	Yes	1935
Edwin Duncan Hall	ED 313	110	40	995	24	TEC	TEC	Yes	1965
Garwood Hall	GWH 337	110	45	744	16	CHE	CHE	No	1998
I. G. Greer Hall	GH 219	110	40	778	19	P R	P R	Yes	1950
Katherine Harper Hall	KH 11	110	40	1068	26	TEC	TEC	Yes	1961
Lillie Shull Dougherty Hall	DH 105	110	43	717	16	NUT	NUT	Yes	1962
Living Learning Academic Ctr	LLA 223	110	34	744	21	IDS	IDS	Yes	2003
Peacock Hall	PH 1018	110	56	1365	24	MGT	Cob	Yes	1990
Rankin Science West	RSW 157	110	18	638	35	BIO	Bio	Yes	1970
Reich College of Education	RCOE 237	110	36	735	20	COLLEGE OF EDN	COE	Yes	2011
Sanford Hall	SH 208	110	32	590	18	ENG	Eng	Yes	1968
Smith-Wright Hall	SW 200	110	50	962	19	PSY	Psy	Yes	1940
Turchin Center	TCV 1102	110	80	1354	16	ART	Art	Yes	1985
Walker Hall	WA 308	110	30	505	16	MAT	Mat	Yes	1975

est_replacement_cost	last_renovation	renovated	gross_area	orig_bldg_cost	# floors	\$/sf (replacement)
\$ 23,520,365.00	\$ 3,225,000.00 05		142,672	\$ 5,128,000.00	03	\$ 164.86
\$ 8,591,762.00			18,022	\$ 7,935,951.00	03	\$ 476.74
\$ 2,442,530.00			26,758	\$ 1,000,000.00	03	\$ 91.28
\$ 73,958,760.00			210,000	\$ 47,586,900.00	05	\$ 352.18
\$ 21,599,865.00	\$ 10,000.00 93		90,000	\$ 7,667,500.00	04	\$ 240.00
\$ 10,903,762.00	\$ 900,000.00 94		41,690	\$ 1,197,500.00	03	\$ 261.54
\$ 8,081,131.00	\$ 31,150.00	84	41,278	\$ 400,000.00	02	\$ 195.77
\$ 13,385,234.00	\$ 120,000.00 88		81,887	\$ 1,175,000.00	03	\$ 163.46
\$ 40,721,800.00			114,810	\$ 16,385,481.00	04	\$ 354.69
\$ 8,483,868.00	\$ 58,100.00 83		45,707	\$ 565,000.00	02	\$ 185.61
\$ 11,011,454.00	\$ 13,162.00 92		77,193	\$ 2,878,208.00	02	\$ 142.65
\$ 2,929,621.00			20,538	\$ 310,000.00	02	\$ 142.64
\$ 6,559,226.00			19,167	\$ 3,700,000.00	04	\$ 342.21
\$ 31,767,553.00			130,000	\$ 10,065,500.00	04	\$ 244.37
\$ 19,484,862.00	\$ 2,600,000.00 06		87,232	\$ 3,530,000.00	04	\$ 223.37
\$ 21,826,543.00			124,735	\$ 18,044,850.00	06	\$ 174.98
\$ 13,270,929.00	\$ 50,000.00 86		73,200	\$ 2,057,000.00	05	\$ 181.30
\$ 3,663,109.00	\$ 1,700,000.00 06		25,680	\$ 234,000.00	03	\$ 142.64
\$ 12,403,108.00	\$ 6,500,000.00 00		40,640	\$ 5,815,711.00	03	\$ 305.19
\$ 12,035,739.00	\$ 1,648,800.00 03		52,225	\$ 1,993,000.00	03	\$ 230.46

Vita

Sarah Hooper was born in Atlanta, Georgia and moved with her family to western North Carolina when she was 4 years old. She grew up outside of Asheville in Lake Toxaway, N.C., where she grew up helping with her father's residential contracting business.

She graduated from Appalachian State University with a Bachelor's of Science in Appropriate Technology in May of 2015, and decided to remain at Appalachian State for her graduate career. A lover of architecture, she began the Technology, M.S. program in August 2015. She decided to pursue two concentrations: Sustainable Building Design and Construction, and Building Science.

Outside the classroom, Sarah worked as a graduate assistant in the Office of Sustainability at Appalachian State University. While employed, she assisted with completing the annual Greenhouse Gas Inventory Survey, and developed a carbon offset program platform for university travel, among a variety of other responsibilities.