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Elevating Learning Environments through Biophilic and Student-Centered Designs:

A Case Study of Bethel-Hanberry Elementary School

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I. INTRODUCTION

When Richland School District Two in South Carolina decided to replace Bethel-Hanberry Elementary School (BHES), their vision extended beyond merely updating the school building. They aspired to establish a foundation for a modern pedagogy that prioritizes engaged, inclusive, and nurturing education. The district sought to create a school that would serve as a benchmark for exceptional teaching and learning environments that emphasizes critical thinking, creativity, collaboration, and communication. The district selected Craig Gaulden Davis Architecture (CGD) for its expertise to achieve this vision and its record of designing schools that emphasize the significant role of the facility in promoting academic performance, well-being and safety, and focus primarily on integrating elements of student-centered design and biophilic design.

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The design of BHES is unique for its comprehensive integration of both biophilic design features and learning spaces that support student-centered learning. Delving into the process, project goals and design solutions, this case study attempts to "close the loop," examining the effectiveness of the approach and design features. Because this school replaces the existing BHES, this case study includes stakeholder perceptions of the change, and contrast performance measures taken after the first year in the new school with measures taken in the last year in the old school.

BHES is a public school in Richland School District Two, located at 125 Boney Road, Blythewood SC. There are 754 students enrolled in grades pre-K to 5. The student body is 60% African American, 22% White, 10% Hispanic, and 8% Other. Fifty percent of these students are in poverty according to the South Caroline Department of Education. The school defines its purpose as "developing successful leaders by empowering, engaging and inspiring learners thorough creativity and discovery in a nurturing environment!" District and school leaders, faculty and staff welcomed this case study assessing the performance of the new teaching and learning environments.

This case study presents the design process and goals for the school, a literature review, and a description of the design strategies used to meet the goals. The assessment methodology and results follow with summary and conclusion sections, and a discussion of potential additional research.

II. THE DESIGN PROCESS AND GOALS

CGD led a collaborative and inclusive design process that began by clearly defining the goals of the project with the key stakeholders, including district and school administration, School Board members, teachers, current and former students and parents, a historic society, and community members. CGD emphasized the importance of involving stakeholders in the design process to generate ideas and envision spaces to support the project goals, customize the school to the community and its needs, and to gain community support and buy-in. CGD thinks that an inclusive design process that is transparent and meaningfully engages the community leads to better results.

Using the Construction Manager at Risk project delivery method allowed collaboration at the earliest stage among the architect, contractor, interior designers, and engineering consultants, and school district, school board, community, parent and student stakeholders. Throughout the design process, the architects regularly discussed opportunities and challenges related to building siting, orientation, programming, and form with the entire project team. CGD's initial concept ideas were shared with the stakeholders, encouraging feedback and fostering a strong sense of the value of design and active participation in the design process. Beyond formal presentations, the design team engaged in small group workshops with stakeholder representatives to confirm the building program, discuss project goals, review conceptual plans, gather feedback, and make design decisions that would improve the experience of using the facility. This approach further enhanced the sense of customization and ownership of the building.

As the design process progressed, so did the onset of the pandemic. A positive outcome of the pandemic was the increased reliance on technology for collaborative efforts. The architectural model was transformed into a cloud-based format, facilitating the design and engineering teams' virtual collaboration. Virtual meetings became the primary mode for collaborative discussions throughout the design and development stages.

The community engagement process revealed community traditions and preferences. To discern the types of learning spaces valued by the community, CGD presented a variety of design solutions, including materials and aesthetics, safety measures, diverse indoor and outdoor learning spaces, ways to honor school cultures and histories, and strategies to foster community engagement. Throughout the design process, CGD transparently reported how community input influenced the design and explained instances where certain suggestions could not be implemented. A School Board member lauded the design process, hailing it as the "best example of full community engagement she had ever experienced."

The resulting set of goals were:

1. A safe facility.
2. A facility in which students and families feel welcomed and a sense of belonging.
3. A facility that fosters student, teacher and staff mental and emotional well-being.
4. A facility that promotes academic achievement and equitable access by providing a variety of learning spaces that support the diversity of students.
5. A facility in which spaces spark creativity, imagination, and ignite a desire for learning and a desire to come to school.
6. A beautiful facility that is cost-effective, durable, and built for ease of maintenance.

Features that stakeholders were attracted to included open spaces with long views, abundant natural light and views to nature, contemporary interior spaces with bright colors, expanses of glass, open stair cases, graphic representations of the school's history and culture, collaborative learning spaces for active learning, and safety features that integrated into the learning environment and did not detract from the school's beauty.

III. LITERATURE REVIEW

CGD's strategy for designing a facility that met the district's goals was based on their research and experience designing for school safety, student social and emotional well-being, student-centered learning, and biophilic design. Below is a literature review related to those four areas.

1. SAFETY

Ensuring the safety of students, staff and visitors is a paramount focus in school design. This encompasses not only safeguarding against intruders but also safeguarding against accidents, encouraging safe interactions among students, and health safety.

Creating a safe school is integral to fostering a humane, nurturing, welcoming, inspiring, and productive learning and working environment. A secure setting allows students to be vulnerable to try, fail, recover and learn. A secure space is vital for instilling comfort and confidence in students and staff, and facilitating optimal learning, teaching, and personal growth. A safe learning environment can directly impact student performance by alleviating stress and anxiety. School design should emphasize not only the physical safety but also scaffold emotional and social experiences.

K-12 leaders can promote a sense of safety and improve overall safety measures by designing secure school environments without compromising the school's identity and welcoming culture. Safety considerations can be integrated holistically and unobtrusively, ensuring that students perceive them positively and contributing to a positive school climate characterized by joy and meaning. Avoiding approaches that serve as constant reminders of potential dangers, such as window bars and metal detectors, is essential, as studies have found them to be negatively correlated with students' sense of safety and not strongly correlated with reducing school violence. Fortunately, many minimally visible measures significantly enhance safety (Committee on Architecture for Education 2018).

The concept of "invisible hardening" design features provides options to create safe and inviting environments. Schools can establish a single entry point for visitors, incorporating a vestibule for greeting, identification, and natural surveillance, while maintaining multiple exit points (Centers for Disease Control and Prevention 2022). Visual connections between entry points and specific outdoor areas enhance monitoring, allowing school staff to quickly identify potential threats. Positive features include video surveillance, bullet-resistant windows, door locking systems, and individual restroom stalls (Committee on Architecture for Education 2018).

Lighting and visibility play a crucial role, with well-lit hallways and stairwells, and open floorplans with long vistas promoting visual connection, natural surveillance, and supervision of student movement. Abundant natural light and thoughtful layout orientation further enhance visibility. Site design considerations, including landscaping, waiting areas, ample space in hallways and corridors and pathways, and creating a clear separation of foot, bus, and car traffic., contribute to student safety and create a welcoming presence harmonious with the community (Centers for Disease Control and Prevention 2017).

Addressing student safety from each other involves clear visibility and natural monitoring to reduce opportunities for bullying and improve detection. Open floor plans can remove areas of isolation where students can be unobserved while also affording areas of refuge for classes and compartmentalization to allow specific areas to be closed and locked from the inside in an emergency. Open sightlines with glass walls or half-glass walls provide transparency between and through spaces to encourage collaboration and connections.

Maintaining the health of students and staff is also essential. To protect against COVID and other airborne pathogens, K-12 school systems can adopt a layered approach that involves circulating clean air and filtering out particulates at multiple levels within each facility. Additional design features can include designing interior traffic patterns and wayfinding to reduce the spread of pathogens, using natural light's UV rays in a robust sanitation plan, reducing the use of high touch elements in such things as door selection and design, elevator and intercom buttons, touchless restroom features that minimize aerosols, touchless water bottle receptacles that replace water fountains, antimicrobial surfaces, and a health room design that isolates ill students and provides a direct path to a dedicated exit without exposing others.

In addition to the inherent value of the school being a safe and educationally effective environment, a safe school can enhance the school's reputation and attract more students and staff. A school with a good reputation for safety can be a key differentiator for parents and community members when choosing a school. Importantly, safe schools contribute to the overall safety and well-being of the community.

2. STUDENT SOCIAL AND EMOTIONAL WELL-BEING

Beyond physical safety, students must feel psychologically safe to be prepared to learn. An overarching goal of the design is to create an environment where students feel welcomed, included, and valued. Regardless of their background, students should step into the school building and grounds and feel, "This space was designed with me in mind!"

Many school-age children grapple with emotional, mental, and social stress, a challenge compounded by factors such as COVID-19 and the increasing prevalence of social media and the internet. This impacts their well-being and significantly influences their ability to focus and learn in school. One study estimates that anxiety and depression rates among children have doubled during the pandemic, with at least one in five children suffering from these disorders (Centers for Disease Control and Prevention 2022). While much attention is rightfully directed towards student support and curricular design, facilities also play a crucial role in supporting children's emotional, mental and social well-being. Additionally, teacher and staff well-being should be a priority for its own sake, but also to support teachers and staff in their support of students.

Among the six core principles the Substance Abuse and Mental Health Services Administration has identified for implementing student well-being and trauma-informed practices within schools are peer support and collaboration, and empowerment, voice, and choice (Highland 2023). The concept of 'ownership' of space and equipment by both teachers and students contributes to a sense of agency in education. Personalized learning environments can be created through the use of flexible furniture and adaptable learning spaces that can be adjusted to suit individual needs. These flexible learning spaces prove to be instrumental in enhancing student well-being by providing choices in seating, encouraging collaboration through adaptable furniture configurations, fostering connections and support among students and between students and teachers, stimulating interest, curiosity, and engagement, and promoting comfort, movement, and inclusiveness. These collaboration spaces are safe and effective learning environments that strike a balance between independence and supervision (Evans 2003).

Reports indicate that flexible learning spaces facilitate student-centered pedagogy, self-regulation, collaboration, and student autonomy and engagement (Kariippanon et al 2018). Modified spaces are reported to be more enjoyable, comfortable, and inclusive, enabling greater interaction (Kariippanon et al 2018). Students are more engaged, on-task, and exhibit increased collaboration and interaction, leading to higher academic results in subjects like English, Mathematics, and Humanities, compared to peers in traditional classrooms (Kariippanon et al 2021). It should be noted that instructional design and approaches have to be modified to incorporate the use of the flexibility afforded by the new facility designs (Kariippanon et al 2020). Moreover, flexible learning spaces play a crucial role in supporting teacher well-being by providing them with the ability to choose configurations, fostering connectivity, and ensuring comfort in their work environment. This dual benefit, enhancing both student and teacher experiences, underscores the positive impact of flexible learning spaces on the overall educational environment.

Additional design factors discussed elsewhere also promote student well-being and mental health through restoration from mental stress and comfort such as daylighting, views to nature, and interaction with nature (Evans 2003). Our own research in biophilic design in schools has shown not only a significant increase in student performance, but also the calming effects that support student well-being (Determan et al 2019).

3. STUDENT-CENTERED LEARNING

3.a. Student-Centered Learning versus Teacher-Centered Learning

In the traditional, teacher-centered learning model, teaching is direct instruction by a teacher and students are passive recipients of the information. Instruction typically follows a standard, textbook-focused approach. In the student-centered learning model the teacher coaches and facilitates students' learning and comprehension of the subject material. The students have more agency and play a more active part in the learning process.

One main purpose of student-centered learning is to make learning more personalized for each student, adapting to each student's uniqueness. Because student-centered learning is personalized, it can take many different forms, requiring the flexibility to support the simultaneous use of multiple instructional strategies. Additionally, the instructor provides students with opportunities to learn independently, and with and from each other, recognizing the social nature of learning. Student-centered classrooms are flexible, which means that students can group in various ways from individual, to pairs, to everyone in the class, depending on the task at hand, versus the typical, static arrangement of desks and other furniture.

The focus of student-centered learning is on cooperation, both between students and between students and teachers. In a healthy learning environment, students work together to support and learn from each other, and teachers coach students in the social and emotional skills they need to do so effectively. Teachers encourage students to become more self-directed, to think critically, solve problems, and draw conclusions. This approach encompasses many different methods such as project-based learning, problem-based learning requiring critical or creative thinking, hands-on learning, inquiry-based learning, personalized learning, social-emotional learning, active learning experiences such as simulations and role plays, learning games, and team-based learning. Often, students have to seek and access the information they need, making flexible technology in the classroom necessary.

3.b. Why Student-Centered Learning Matters

Students learn better when they are personally and actively engaged in learning, and feel they have some ownership over their education and choice about where and how they learn. The personalized, self-directed approach leads to increased engagement and motivation to learn and more positive attitudes towards the subject being taught. The student-centered model is more effective for a greater retention of knowledge and depth of understanding by connecting the learner with a wider range of experiences than just listening or memorizing. This model has proven to be successful in raising students' achievement levels, increasing graduation rates, and increasing graduates' completion of college admissions-required coursework.

With student-centered learning, students engage in active problem-solving. They are encouraged to ask questions and think critically about the information they learn. As a result, they develop strong critical thinking skills that they can apply in all areas of their lives, promoting life-long learning.

The social-emotional aspect of student-centered learning involves the development of skills to collaborate, manage and express feelings, resolve conflict, and make responsible decisions, helping students communicate and work together effectively, improve behavior toward each other and teachers, improve attitudes about themselves and school, decrease emotional stress and depression, and improve academic achievement.

3.c. Facilities

Well-designed buildings can be a catalyst for education excellence. Student-centered learning requires facilities that support a full range of learning and teaching methods, and support collaboration including individual, one-on-one, small group, and large groups. Teachers are more effective, and students benefit, when they collaborate more (Leana 2011). School facility design should prioritize accessibility and inclusivity to ensure that all students, including those with disabilities or mobility limitations, can fully participate in learning activities. This includes designing classrooms, hallways, and other internal and external spaces. Facilities that support student-centered learning also promote equity by recognizing that students arrive with different learning styles and needs, and require different types of support and methods of instruction to be successful.

The notion of what a classroom is changes from a static design with students in rows of desks, offering little flexibility to change the classroom organization, to one where teachers have the flexibility to tailor the space to match their pedagogy, and students are encouraged to participate in designing and arranging their classrooms as inspiring workplaces. In a student-centered learning facility, an agile, active learner is supported within an agile, active social and physical learning environment (Nair 2019). The facility can be adapted to meet students' and teachers' needs as those needs evolve over years. Some spaces can be designed to be special purpose spaces with rich resources such as access to information technology to apply theoretical learning to real-world problems or to a specific type of activity such as a maker space. Student-centered learning extends outside of the classroom, making the entire building and outdoor facilities potential sites for learning. How well students learn is impacted by the emotional state the culture and facilities foster and how they feel about the school. Facilities should be welcoming, safe, and create a positive school climate. For example, it is possible to break down the anonymity of large school settings through the creation of physical learning communities where smaller groups of students and teachers share a common space. Providing an educational setting that is high quality and memorable can be both conducive to better learning and be symbolic of the priority that is given to the students and their learning.

The quality of the physical environment such as the quality of the lighting, air, noise and temperature can reduce absenteeism and improve student performance, with a greater impact for low-income and minority students (Cheryan et al 2014, Mendell & Heath 2004, Ackley 2017, Maxwell 2016, Benka-Coker et al 2021). Flexible classrooms lead to higher test scores, and students reporting more positive attitudes towards school and exhibiting more positive social behaviors, greater engagement in learning, and fewer disruptive behaviors (Nair 2019).

Technology can enhance student learning by providing access to a wider range of resources and facilitating communication and collaboration. School facility design should incorporate technology infrastructure that meets current needs and is adaptable to future development.

The entryway sets the tone, as a first impression and experience of the building. It should be welcoming, especially for children who can easily be intimidated, overwhelmed and made anxious. For students, the entryway should provide a sense of place and belonging with a positive and social tone (Nair 2019). Classrooms are organized around a shared space rather than along hallways, eliminating the "rigid separation" between classrooms. What is typically hallways space used only to move students now becomes teaching, learning, collaboration and social space (Nair 2019).

4. BIOPHILIC DESIGN

The biophilia hypothesis posits an innate human affinity for nature, and that nature contributes to human physical and mental health and wellbeing, as well as cognitive perfor-

mance (Wilson 1986, Kellert & Calabrese 2015). Humans react positively not only to direct exposure to the natural environment, but also to mimicry of the natural environment (Appleton, 1996). Biophilic design in architecture attempts to design buildings that meet not only their functional goals but also connect with and support people on an emotional and psychological level using such things as views of and access to the outdoors and nature, natural lighting, imitating natural environments with lighting and patterns, and natural materials (Kellert et al. 2011).

Studies have provided evidence for the biophilia hypothesis in school settings. In schools that incorporated biophilic design elements, students had higher test scores, reduced stress, increased attentiveness and memory, improved cognitive functioning and psychological wellbeing, more positive attitudes and perceptions of school, and increased participation. These design elements have these effects on all students, regardless of ethnicity, age, or gender, with the impact greater for students from disadvantaged backgrounds. Teachers reported higher teaching effectiveness and job satisfaction, and lower stress (Besthorn & Saleebey 2003, Sheets & Manzer 1991, Ulrich 1993, Joye 2007, Woodward & Zari 2018, Bolten & Barbiero 2020, Heerwagen 2009, Kellert & Wilson 1993, Kellert et al. 2011, Determan et al 2019, Kaplan,1995, Benfield et al. 2015, Wu et al. 2014, Li & Sullivan 2016, Dadvand et al 2015).

Browning et al (2014) and Kellert & Calabrese (2015) categorize biophilic design into designing for three types of experiences:

- direct experience of nature such as living elements, natural light, air and landscapes
- indirect experience or natural analogues of nature such as nature mimicry, natural materials, images of nature, natural patterns, shapes and forms, and environmental processes
- spatial configurations in nature and the experience of space and place such as prospect and refuge, organized complexity, mobility and way finding.

Browning et al (2014) define 14 patterns of biophilic design in architecture, of which seven are discussed below.

4.a. Visual Connection with Nature

A view to a natural area allows one to shift mental focus from the indoor and proximal to the outdoors. Determan et al (2019) suggests that views to nature play a significant role in providing students with opportunities for mental breaks throughout the class period and Browning et al (2014) states that views to nature reduced stress, lead to more positive emotional functioning, attitude and happiness, and improve concentration, engagement and attentiveness. Li & Sullivan (2016) found that classroom views to green landscapes cause significantly better performance on tests of attention and increase student's recovery from stressful experiences. Matsuoka (2010) found that the quantity of trees and shrubs within the exterior view was positively correlated with standardized test scores and graduation rates.

4.b. Dynamic and Diffused Daylight

The experience of natural light is fundamental to human health and wellbeing, inducing a positive psychological effect, promoting positive emotions, and enhancing alertness, creativity, cognitive processing speed, concentration performance and social behavior (Heerwagen 2009, Heerwagen 1990, Almusaed 2010, Kellert & Calabrese 2015, Eitland et al. 2018, Meng et al. 2023, Evans 2003). Research in hospital settings shows that patients in bright sunlit rooms recover more rapidly, show reduced pain levels, take fewer strong analgesics, and stay in the hospital fewer days than patients who are in more dimly lit rooms (Walch et al. 2005, Evans 2003).

In addition to the direct benefits of natural light, in interplay with other design features, natural light can create patterns, shapes, and forms of light and shadow, and diffuse, indirect, and variable light (Kellert & Calabrese 2015). Natural light can also create movement as it crosses the sky during the day, and create spatial perceptions, making spaces appear larger or more enclosed.

In a school setting, in a large study Heschong et el. (2002) found that students with the most classroom daylighting progressed 20 percent faster on math tests and 26 percent on reading tests in one year than those with the least daylighting. Similarly, students with the largest windows progressed 15 percent faster in math and 23 percent faster in reading than those with the least. These findings were consistent across curricula and teaching styles.

4.c. Complexity and Order

To engage the human mind, a space has to be sufficiently complex to be interesting and not boring, but not so complex as to be overwhelming or confusing. This is the balance sought by the complexity and order pattern similar to structured hierarchy patterns found in nature, providing rich visual information and positive cognitive and emotional responses. The complex patterns can also evoke another biophilic pattern, mystery. The desire to explore to learn more is fundamental to education. Unlike many built environments designed for immediate understanding, biophilically-minded designs facilitate wayfinding and comprehension at a broader level while simultaneously inviting attention and encouraging exploration at a more detailed level (Ryan et al 2014, Browning et al 2014, Kaplan and Kaplan 1989).

4.d. Prospect

Humans feel a sense of security and control when they have an open and clear view of their surroundings. The prospect pattern provides an undisturbed and unrestricted view over a relatively large area to allow for surveillance. This provides a sense of freedom and safety (Rai et al 2020).

4.e. Refuge

Refuge is a space that provides the feeling of withdrawal from stressors, both physical and mental. The space feels welcoming and protective, and provides an opportunity for stress relief and restoration. It can be used both individually and in small groups (Browning et al 2014). There is a connection between refuge and prospect. To feel most secure, humans like to be able to observe their surrounding environment to monitor for approaching threats (Dosen and Ostwald 2013). While offering a feeling of refuge, the space must remain connected to the larger environment so that students are not disengaged (Appleton, 1996).

4.f. Material Connection with Nature

Spaces with material connections to nature feel authentic and rich. These spaces may be constructed with materials produced by nature such as wood exposed to viewing and touching, or incorporate living nature such as a tree canopy or living plants. Dadvand et al 2015 reports a connection between incorporating natural elements such as a school ground tree canopy and vegetation and the cognitive development of school-age children.

IV. DESIGN STRATEGIES AND FEATURES

1. A SAFE FACILITY

Safety, both physical and psychological, are essential elements of any school design. Physical safety means that students are safe from harm, intruders, and violence. Psychological safety means that people feel safe in the building and on the grounds, and connected to adults and other students. Key to CGD's approach to safety in the BHES design was unobtrusive or invisible safety features. Another was to not sacrifice other goals for the school to meet the safety goal but to find a way to have both.

Natural light was important to the approaches used to achieve many of the design goals. Often in school designs, the number windows is reduced or windows are eliminated because some people feel that this is safer from external threats. The BHES school design relies instead on the Crime Prevention Through Environmental Design evidence that natural surveillance and transparency are more protective than closing off lines of sight, windows are used extensively in the front entrance, corridors, classrooms, media center, cafeteria and between interior spaces (Crowe & Fennelly 2013). To allow for this extensive use of glass, the design includes ballistic glass at the front entrance, bullet resistant film on all exterior windows, and Level 3 (the highest level of safety glass) in the interior. The abundant natural light and visibility throughout the learning spaces provide clear lines of sight inside and outside of the building and promote surveillance. Being able to see a long distance is a biophilic design strategy called Prospect. This strategy has been proven to help occupants feel safer, as they can see there is no danger within their view. The clear lines of sight and open layout also facilitate visual connection with and supervision of students.

As drivers enter the site the approach to the school is both long and winding. This is intentional to provide space for cars to stack off of the public roads, but also so security staff can observe, assess and act on any unusual movement or behavior long before the driver reaches the school front door.

The entrance areas were designed to facilitate pedestrian and vehicular safety. Separate car and bus loops converge on opposite sides of a common pedestrian drop-off area that leads to a single point of entry into the school (Figure 1).

FIGURE 1

This design had the additional benefit of efficient land use. The entrance is into a secure vestibule where visitors are identified and checked by the administration staff, before they are allowed into the school. Vehicular traffic is confined to the front and sides of the school allowing pedestrians to have a vehicle-free, safe access to fields and outdoor play areas.

The playground is situated between the two classroom wings for visibility from the classrooms while limiting access including fencing along the one open side. The school is compartmentalized so that various areas are secured should the school need to be locked down (Figure 2). Additionally, the classroom pods located beyond the main street corridor are designed to function as separate buildings so if one pod is compromised by fire or security problem, students may exit into an adjacent pod and be safe. The door numbering system for exterior doors allows emergency personnel to easily identify locations in the building, and a road encircling the facility allows full fire truck access.

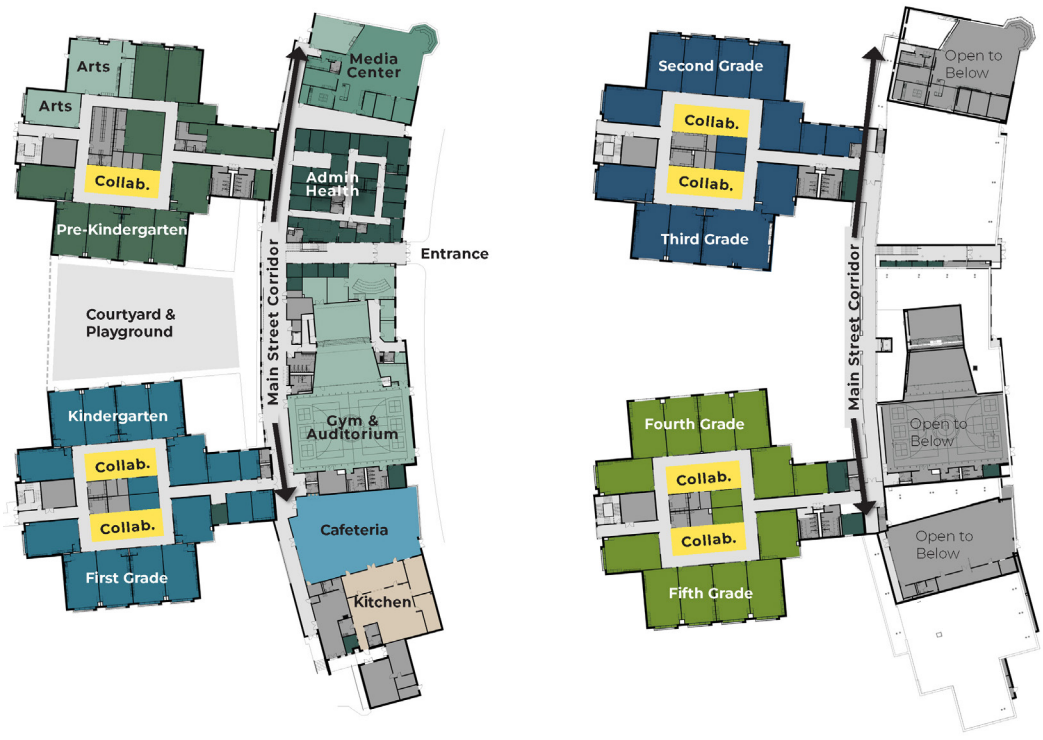
2. A FACILITY IN WHICH STUDENTS AND FAMILIES FEEL WELCOMED AND FEEL A SENSE OF BELONGING

Students learn better in environments in which they feel comfortable. Through biophilic and student-centered elements, students are made to feel welcomed in BHES. Anchoring the school in its community and history gives students a sense of belonging.

Students enter the building into an inviting, bright, colorful, daylight-infused two-story space (Figure 3). They travel to their classrooms along an easy-to-navigate, curved central "Main Street" corridor with views to nature, natural wood ceiling and rails, dappled sunlight from the east-facing frit-patterned glass, and biomorphic hexagonal-shaped acoustical wall panels that create a honeycomb pattern. The fritted glass casts a dappled light path, like walking under a tree canopy (Figure 4). The facility was strategically situated on the site to optimize daylight for its programmatic use.

FIGURE 3

FIGURE 2



Classrooms receive dynamic northern and southern light through large windows that allow a constant shades-up view to nature. The public spaces, used less often and primarily earlier in the day or after sunset, receive the less controllable western and eastern light. Hexagon-shaped ceiling tiles and light fixtures create more honeycomb patterns in the media center. Many of the spaces, such as the media center and cafeteria, feature soaring ceilings with views to the outdoors and vibrant color palettes to inspire joy, wonder and awe (Figure 5). Awe experiences "increase feelings of connectedness, increase critical thinking, skepticism and increase positive mood." The media center features an octagonal learning corner, dynamic floor patterning, and a grand panoramic view of the lush natural environment surrounding the school. The layout and furnishings provide a variety of spaces including the 'campfire' area with tiered seating, colored glass, and biomorphic forms. The media center is a colorful light beacon at night drawing attendees for school meetings and community gatherings (Figure 6).

Several techniques were employed to break down the scale and create simple wayfinding in what otherwise would be a massive, daunting building for young students. First, each large space is broken down into smaller more easily understandable modules. For example, the main street corridor is constructed on a segmented curve that visually reduces the overall length of the space. It is further broken down by undulating and alternating ceiling applications, and

FIGURE 4

FIGURE 5

FIGURE 6

broken down further still by nooks and floor patterning. The colors throughout the building create a cohesive thread and are referenced for ease of wayfinding. The classroom pods are color-coded to signify the grade level. The classroom exteriors feature playful and age-appropriate colors, geometric forms, materials and textures. The school has a welcoming exterior including the extensive use of windows, colored glass and metal panels, bright colors at points of egress, a tall glass entry and a colored glass corner turret at the media center (Figures 7 and 8). Outdoors, students are encouraged to play and learn.

Ties to the community and history were included in the school to create a sense of place and belonging. BHES was Blythewood's first African American school and one of the first schools in South Carolina to be accredited by the Southern Association of Colleges and Schools. The school honors its namesake, South Carolina education pioneer Annie E. Hanberry, the original school, and other elements of its history with graphic displays throughout the building, especially in its corridors and cafeteria. The community meetings helped ensure the integration of history and the local community appropriately in the design. One outcome was the decision to keep the old gymnasium for community use. As a part of the plan, this beloved building with historic significance to the community will be restored and surrounded by a park.

FIGURE 7

FIGURE 8

3. A FACILITY THAT FOSTERS STUDENT, TEACHER AND STAFF MENTAL AND EMOTIONAL WELL-BEING.

Schools focus not only on student academic success but also on mental health and emotional and psychological success. Areas were included in the design that provide students with more intimate, secure spaces and nooks where they can escape the crowd, reflect, work, or have a one-on-one conversation with a friend or teacher. These areas often provide views of nature, a feeling of refuge and the opportunity to learn in a social environment. Nooks on the first level in the main street corridor allow for unimpeded views through the corridor and to the playground via a small window and also provide a place of withdrawal from the main flow of traffic with walls on three sides. Similar nooks on the second level in the main street corridor provide the same views and refuge, and views to the first level (Figure 9). Additional areas for refuge are provided in the collaboration spaces and media center with small group rooms, tables, individual chairs, carpeted floors for sitting, and tiered seating.

The abundant natural light, views of nature, and biophilic patterns promote calm, well-being, and a positive emotional experience. After studying the sun path, a window frit pattern was designed to create a shadow simulating the dappled light through a tree canopy. This dynamic and diffuse daylight pattern has been proven to reduce stress and have a positive effect on circadian rhythm.

Social emotional learning is supported by window nooks and collaboration spaces. If a student is reaching a trigger point in class, a para-educator and student can take a respite in a window nook. This is a safe space for a quiet lesson to help the student learn how to manage emotions. The collaboration spaces afford the opportunity to learn and communicate in a social setting. Flexible learning spaces are inclusive and empowering in that they foster trust, and transparency, and offer choices about how and where students learn (Figure 10).

4. A FACILITY THAT PROMOTES ACADEMIC ACHIEVEMENT AND EQUITABLE ACCESS BY PROVIDING A VARIETY OF LEARNING SPACES THAT SUPPORT THE DIVERSITY OF STUDENTS.

BHES has a diverse population of students. Equity in the school environment is based on the understanding that all children are unique and will have the opportunity and supports needed to succeed academically and socially. Student-centered learning makes education personalized for each student and their learning needs resulting in higher achievement outcomes and helps students think critically, collaborate, create and communicate. Student-centered learning exists inside and outside the classroom, making the entire building and outdoor facilities potential sites for a variety of effective teaching and learning opportunities.

Student-centered learning provides teachers with the flexibility to simultaneously use multiple instructional strategies including direct, indirect, experiential, independent, and interactive. It also allows teachers to practice differentiation, preparing customized lessons based on each student's competency. These approaches require more space than is typical. At BHES, rather than expand the classroom sizes, which would significantly increase the size of the building and budget, classrooms are clustered

FIGURE 9

FIGURE 10

by grade in learning communities around open and colorful collaboration spaces. Teachers are then able to send small groups of students outside of the classroom while maintaining visual contact. A variety of furnishings in the collaboration space allow students to choose where and how they learn. Collaboration allows students to learn social skills, empathy, critical thinking and to take responsibility for their own learning. Additional spaces for students include small group rooms adjacent to the collaboration space, a makerspace, and small seating nooks in the main corridor.

Student-centered classrooms use mobile, flexible and reconfigurable furnishings where teachers can arrange students, or students can arrange themselves, in various ways from individuals, to pairs, to small groups, to everyone in the class, depending on the activity. In BHES, an agile, active learner is supported with an agile, active social and physical learning environment. Teachers have the flexibility to tailor their classroom space, with student participation, in ways that align with the pedagogy and become effective and inspiring learning places. With the option for small group work, teachers can encourage soft skills such as communication, teamwork, patience, and empathy. Small group rooms facilitate students who have demonstrated responsibility being able to work outside the classroom. The nooks and separate seating allow for students to separate for individual time and work.

In addition to outfitting classrooms with flexible furnishings, the spaces outside the classroom help teachers make learning more fun and effective by engaging students as active participants in their learning. For example, the media center supports student agency by offering choices in seating types and configurations. Students may choose to study individually, or choose a collaboration space to engage, learn and create together. Groups may gather in the campfire space for interactive curricula and activities or for storytelling. Even in the main street corridor, window seats are strategically placed to offer opportunities for students to think, study, communicate and connect with one another or a teacher. Students can choose where they learn best. Variety caters to a neurodiverse learner population. Agency fosters empowerment and inclusion, an important goal for this ethnically diverse student body.

5. A FACILITY WHERE SPACES SPARK CREATIVITY, IMAGINATION, AND IGNITE A DESIRE FOR LEARNING AND A DESIRE TO COME TO SCHOOL.

Students imaginations are engaged as soon as they walk into BHES' bright and colorful entry hall. The playful, biophilic space helps create a sense of wonder, encouraging creativity. Sensory learning is employed throughout the building. Colors, shapes and patterns engage students in creative and scientific thinking, problem solving, and exploration. Hexagon-shaped acoustical panels on the walls in the lobby and floating above the octagonal campfire corner in the media center is a geometry teaching opportunity. The moving shadow patterns created by the curtain wall frit is a science lesson. Sensory and biophilic design features are intertwined throughout the building and grounds to nurture a positive emotional experience and to enhance cognition. The building itself is an expression of creativity and part of the learning experience. Intentional design elements can seamlessly integrate with science, technology, engineering, art and math (STEAM) standards. For example, using geometric shapes and patterns in ceilings and floors enhances the aesthetic appeal while also providing a visual connection to science and mathematical concepts.

6. A BEAUTIFUL FACILITY THAT IS ALSO COST-EFFECTIVE, DURABLE, AND BUILT FOR EASE OF MAINTENANCE.

Many energy and conservation measures were implemented in the design. The design incorporates a limited amount of exterior-facing glass, to manage heat gain and loss. The glass has an excellent U-value and solar heat gain coefficient, far exceeding minimum code standards. Exterior and interior shading devices were strategically placed. Additionally, the abundance of natural light allows the facility to reduce the use of artificial lighting, reducing power use and cooling needs. A reflective white roof was selected for the entire structure to reflect rather than absorb light to reduce cooling load and contribute to reducing the urban heat island affect.

The CGD team gave special attention to the building envelope and energy efficient light fixtures and equipment. Low usage plumbing fixtures along with sensors reduce the amount of water and sewage use. Durable and sustainable materials were selected for both interior and exterior finishes. The exterior finishes are local brick and block, metal panel, and glass storefront/curtain wall. Limiting the number of finishes within the palette allows for less maintenance. The buff color of the brick relates to the sandy surrounding area while the charcoal-colored brick is used in places of shade and shadow as a relief in form thus making the building feel of the place while also providing a contemporary aesthetic that is punctuated with vibrant metal panels and glass. State of the art HVAC equipment was used to provide high air quality, including fresh air intake, and prevent climate control issues occurring from the hot, humid region. Electric air hand dryers are used in the restrooms, significantly reducing the school's use of paper. Water bottle filling stations are used to reduce the spread of illness. Interior materials include locally sourced sustainable carpets. All of the acoustical wall panels are not only formed to invoke nature but are also made from natural materials and certified by the Forest Stewardship Council ensuring that the wood came from responsibly managed forests.

Prior to construction, the Construction Manager at Risk conducted a comprehensive Building Information Modeling (BIM) review and coordination effort. This meticulous process involved close collaboration between the design team and the contractor to ensure the project plan would be implemented well, on time and on budget. At the beginning of construction, steel prices experienced a significant surge. The design and engineering team, in close partnership with the contractor and owner, worked to mitigate the impact of the steel price escalation. The design team modified the design, reducing the reliance on steel and lowering construction cost.

V. ASSESSMENT METHODOLOGY

To understand the design approach and features, the authors interviewed the architects and interior designers. We submitted a survey to all students and their parents in grades 3-5, teachers in grades K-5, and administrators, to study the design goals versus the users' perception of the performance of the school. The survey was anonymous and completed online. Three hundred and twenty-five students, 53 teachers, 41 parents, and six school and district administrators and school board members completed the survey. To enrich our understanding of the responses, we interviewed a sample of students, teachers and administrators.

The surveys included Likert scale and short answer questions. A five-point Likert scale (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree) was used for teachers, parents and administrators for the discrimination of opinion while a three-point Likert Scale (Agree, Neutral, Disagree) was used for students because that discrimination is sufficient for the purpose of this study, are valid, and preferable to larger scales for children (Alan & Kabasakal 2020, Allen et al 2018, Coombes et al 2021, Mellor & Moore 2014).

Additionally, state, district and school-level data relating to academic performance, student behavior and teacher retention were analyzed. Standardized test and survey results (MAP testing, SC Ready, and the State Climate Survey) from the first year in the new school (2022-23) were contrasted with those measures from the last year in the old school building (2021-22).

VI. ASSESSMENTS RESULTS

A year after the school opened in the new building, the authors gathered data to explore how well the facility met district goals, as well as assess the biophilic and student-centered design approaches.

1. A SAFE FACILITY

Survey questions related to safety found that 80% of students reported feeling safe and 82% of teachers and 100% of administrators reported that the safety measures have helped to create a safe learning environment. In a 2023 Gallup Poll, 38% of parents fear for their children's safety when they drop them off at school. When BHE parents were surveyed, 95% reported that they feel that their children are safe in the school. When students and parents were asked how they feel differently in the new school, one of the most common answers was that they feel safer. Figure 11 shows all safety-related survey questions aggregated by respondent group. See the Appendix for the individual questions.

The school improved in every safety-related South Carolina School Climate Survey measure, shown in Figure 12. The comparison of the first year in the new facility versus the last year in the old facility shows a 9.8% increase in students

FIGURE 11

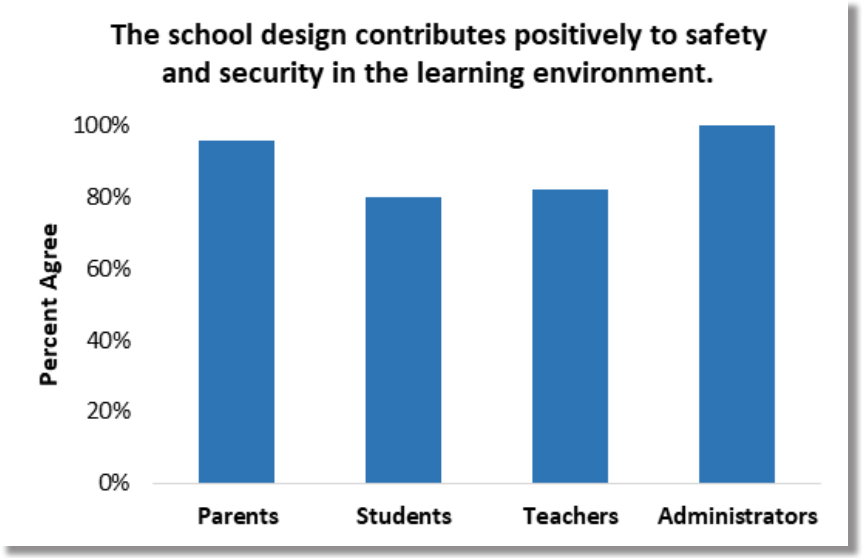
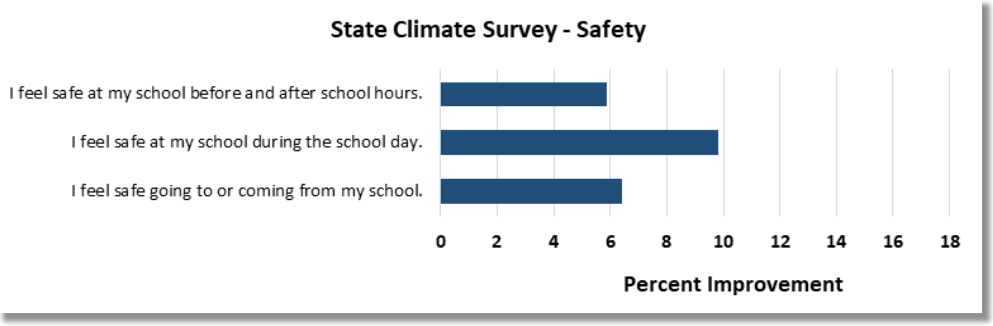


FIGURE 12



feeling safe at school and a 5.9% increase in students feeling safe before and after school.

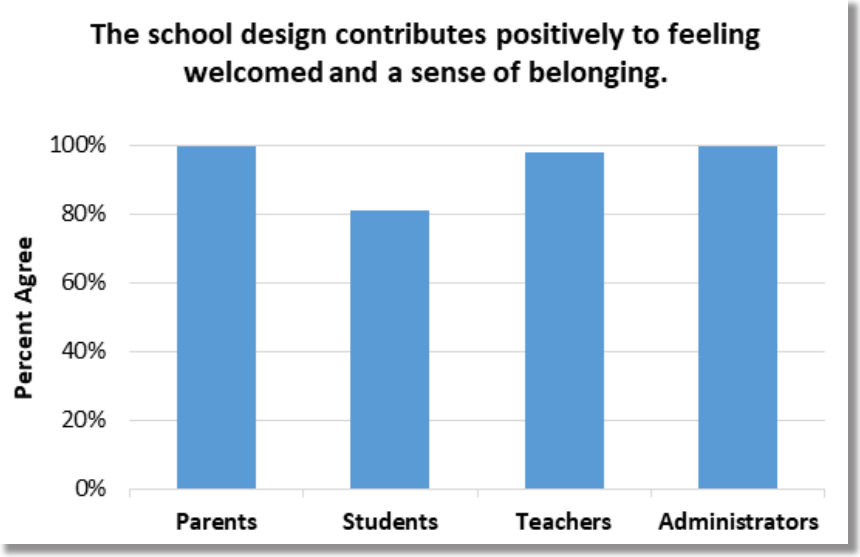
In an interview, assistant principal Dr. Hamilton said that parents, teachers, and staff are definitely feeling much safer. She credited the reduction in entry points and the numbering of the doors for quick communication. Students mentioned feeling more secure and connected because they can see what is around them and know that teachers can see them even when they are working outside the classroom.

2. A FACILITY IN WHICH STUDENTS AND FAMILIES FEEL WELCOMED AND FEEL A SENSE OF BELONGING

Survey questions related to feeling welcomed and a sense of belonging found that 77% reported feeling welcomed and 84% of students reported liking the new school. In the survey of parents, 100% reported that their family feels welcomed and 100% reported that they like the new school. In the survey of administrators and parents, 100% said that the graphic displays of the school's history throughout the school promote a sense of community. In the teacher survey, teachers responded to the question "Does the design of the new school promote a sense of community and belonging among students and teachers? If so, how?" Ninety-five percent of respondents reported yes, with the pod design and collaboration spaces receiving the highest number of positive comments. A few teachers mentioned that the pods create more community within grade levels, but less community across grade levels.

Figure 13 shows the average of all survey questions related to feeling welcomed and a sense of belonging aggregated by respondent group. See the Appendix for the individual questions.

FIGURE 13



Comments from the interviews included a student saying "it's a really warm feeling when I walk into the school, I think it is very welcoming." A literacy coach said, "The picture and the quotes from Miss Hanberry almost brought tears to my eyes. To know the history of the school and to know her and what she envisioned for this school, and that you are a part of her legacy for generations of students. I get chills just thinking about it." A student agreed, saying "It makes me feel a connection to the history of the school. The picture of Miss Hanberry in the cafeteria makes me feel like she's still here. "

3. A FACILITY THAT FOSTERS STUDENT, TEACHER AND STAFF MENTAL AND EMOTIONAL WELL-BEING.

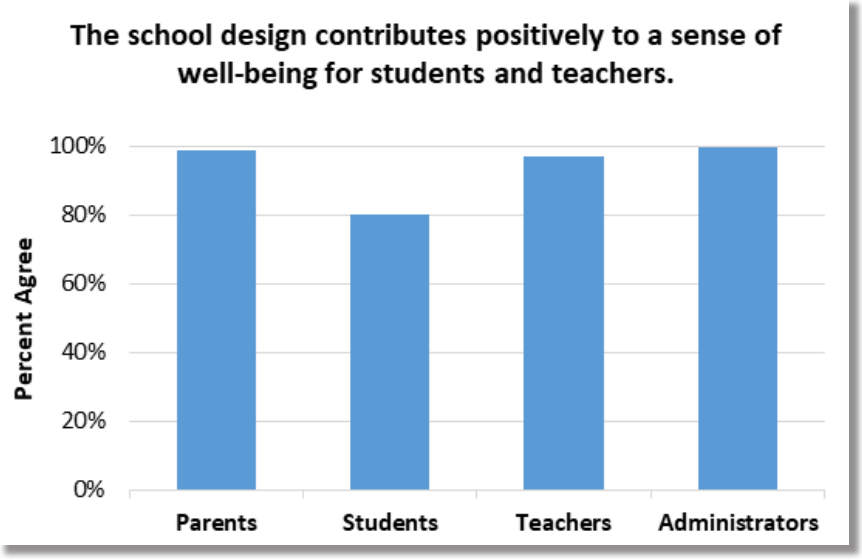
Survey questions related to feeling a sense of emotional well-being found that 66% of students reported feeling happier in the new school, and in the survey of parents, 100% reported that their children are happy in the new school. Student comments include, "I don't really know how to explain it but the colors just make me feel happy, safe and at peace," and "In the new school building, I feel safe, loved, happy, comfortable, excited, and smart." A fourth grader commented "I think students are 1,000% happier here in this beautiful new school. We walk in and go 'Wow. Just Wow.' Some people miss the old school but this one makes you feel more open, mindful, and especially cheerful." When students were asked if there are things about the school that make them feel happy, the most frequent responses were the playground/ outside, teachers and staff, friends and classmates, the classrooms, the colors and patterns, the light and windows, the library, and the cafeteria.

In the survey of teachers, 85% reported that features such as the window seat nooks support social-emotional learning. One teacher commented, "I had a student who was emotionally taxed. He asked to sit on our window seat and look out at the trees as a way to self-monitor until he was ready to join the group." A literacy coach said, "I feel that in this new space really supports the whole child, not only just the academic part, but the social, the emotional well-being of students." A student said, "I feel recognized at my school," and another said, "I feel refreshed and new like the new school." Another student commented, "I'm in just a happy place when I'm at school. It helps me learn because I don't work better under pressure. And being able to move around and go in all these different spaces in the school helps relieve the pressure that I have sometimes." When students were asked what caused them to feel differently in the new school building, by far the most provided response was

that there was more space and more opportunity to move around. The next most common answers were that students feel safer, more comfortable, more alert and more connected to nature.

Figure 14 is a graph showing all survey questions related to well-being aggregated by respondent group. See the Appendix for the individual questions.

FIGURE 14



4. A FACILITY THAT PROMOTES ACADEMIC ACHIEVEMENT AND EQUITABLE ACCESS BY PROVIDING A VARIETY OF LEARNING SPACES THAT SUPPORT THE DIVERSITY OF STUDENTS.

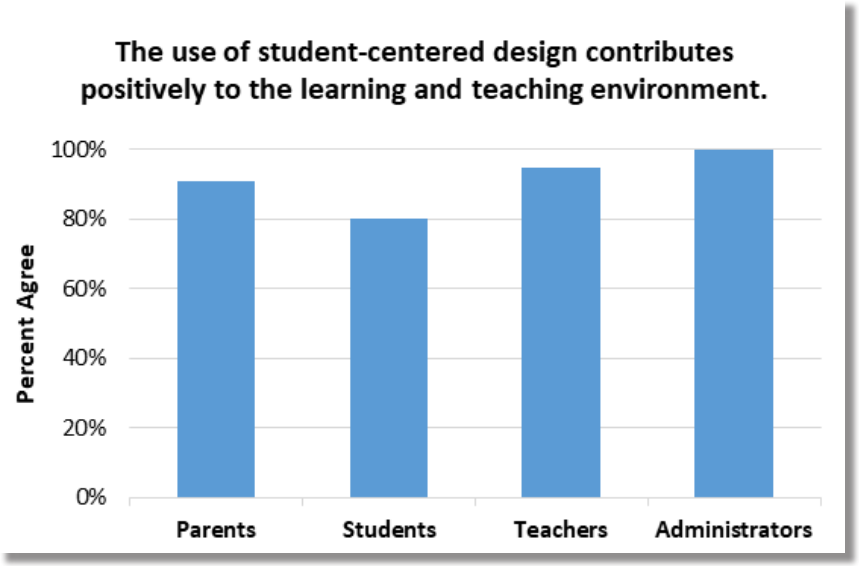
Survey questions related to student-centered learning found that 76% of students reported that the building helps them learn, 79% reported that they like having choices about how they learn, and 88% reported that they like having collaboration spaces to work with classmates. In the survey of teachers, 98% reported that the new school facilitates improvements in student learning, 100% reported that the new building promotes student-centered learning by supporting a range of teaching approaches, 96% reported that the collaboration spaces contribute to a positive learning environment, and 96% reported that the building offers students with different learning styles a variety of ways to learn. In the survey of parents, 91% reported that the new school has improved their child's learning experience. In the survey of administrators, 100% reported that the new school facilitates improvement(s) in student learning and promote student-centered learning. Figure 15 is a graph showing all survey questions related to the variety of learning spaces aggregated by respondent group. See the Appendix for the individual questions.

Students were asked how they learn differently in their new school building. The most frequent answers were the open and flexible spaces inside and outside of classrooms, working in the common areas, technology, hands-on activities, the windows, sunlight and the views to the outside, quiet places and places to be alone, and working in groups. Students reported that it is easier to learn, focus, think and be creative in the new building.

Teachers were asked if the new school supports being more innovative in their teaching. Ninety-eight percent of the teachers said yes. One fourth grade teacher said, "Being in this building forces me, a little bit more, to come up with more modern ideas. Being able to go to different parts of the building and do things we've never done before has been an amazing experience." They were also asked if the new school facility design has a positive effect on student learning, how? The most frequent responses were the common collaboration spaces and small group areas, including the variety of collaboration spaces, the classrooms, the natural light, and technology.

Teachers were asked if the new school design accommodates students with different learning needs, abilities, and backgrounds. In the survey results, 100% find that the media center offers students with different learning styles a variety of ways to learn and 98% of teachers responded that the new school design helps students use

FIGURE 15



different spaces for various learning activities. One teacher responded, "I think the architectural design lends itself to an equitable and culturally responsive environment for all students to feel like the school is their school and to fee welcomed." Another stated, "The design allows for all students to feel welcomed and does not single out a particular culture, ethnicity, or gender," and another teacher said, "Students feel like this is a school that was designed for them to get whatever they need and learn how they learn best." Of the teachers who answered the question "if school design accommodates students with different learning needs, abilities, and backgrounds, please explain how," 12 mentioned the variety of open spaces available for different learner types, and the accessible doors, hallways, bathrooms, sinks and classrooms. Three teachers said they would like to have a separate special needs playground.

Comments from the interviews included a literacy coach saying that the collaboration areas and nooks have been very effective for student enthusiasm, attention and engagement, saying that they are "super beneficial and amazing, and that students can work collaboratively outside of the classroom, but where the teachers can still see them. The spaces, including the makerspace, really support student learning and have really been a tremendous success."

A literacy coach said that the spaces and seating support student learning, give students a variety of options, and accommodate students with different learning styles. Classroom flexibility, students being able to move around, write on the walls, sit on the floor, able to collaborate in the classrooms, having the benches inside of the classrooms and being able to sit and read, are really functional. Students who have lots of energy are able to channel that energy into their stools and be able to rock from side to side. So that's awesome. Spaces have been created for students have been very functional, not just classroom space. Teachers have sent groups of students to the collaboration spaces and had students leading the other students.

5. A FACILITY IN WHICH SPACES SPARK CREATIVITY, IMAGINATION, AND IGNITE A DESIRE FOR LEARNING AND A DESIRE TO COME TO SCHOOL.

In the survey of teachers, 98% said that the building fosters a sense of wonder and curiosity, 95% of teachers said that the use of color has a positive effect on how they feel, 98% said that the natural light contributes positively to the school environment, and 100% of teachers and administrators said that the building itself can be used as a teaching tool. Teachers were asked what in the design of the new school promotes creativity, collaboration and communication. The most frequent responses were the open collaboration spaces and small group areas, including the variety of collaboration spaces, the ability to write on the tables and walls, and the flexible seating and furniture. In the survey of administrators, 100% said that the building design fosters a sense of wonder and curiosity. A teacher described the natural light and the building itself inspire curiosity. When walking down the halls, my students are talking about shadows and light. One fourth grade student said that she notices the details in the building every day and thinks "Who thought of that? I need to go talk to them right now to know how they thought of this!... There's so much to learn just from the building materials, colors, shapes, and patterns, and a little math practicing lines and symmetry just by looking at the ceilings."

6. A BEAUTIFUL FACILITY THAT IS ALSO COST-EFFECTIVE, DURABLE, AND BUILT FOR EASE OF MAINTENANCE.

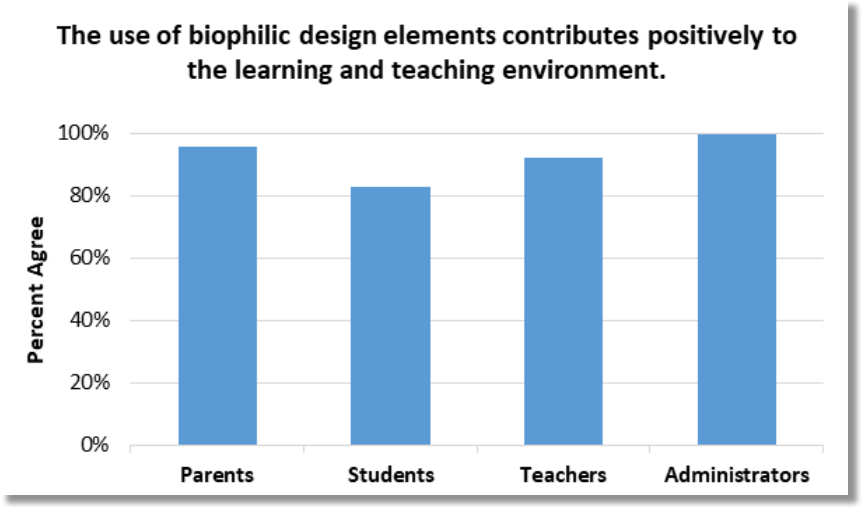
The project was completed 10.25% under budget, with a project cost of $38.77 million versus a budget of $43.20 million.

7. ASSESSMENT OF BIOPHILIC DESIGN APPROACH

Students, teachers, parents and administrators reported at very high rates that they think the biophilic design elements contribute to the learning and teaching environment. Figure 16 is a graph showing all survey questions related to biophilic design aggregated by respondent group. See the Appendix for the individual questions.

Teachers were asked if they think that the incorporation of biophilic design elements (natural lighting, views of and access to the outdoors, nature-mimicking interior elements, etc.) has contributed to a positive learning environment

FIGURE 16



for students. Eighty-two percent of the respondents said yes, 3% said no, and 15% said that there were positive and negative aspects. By far the most common reason for positive responses was the natural light, with teachers mentioning its calming effect, mood-boosting and happiness promoting properties, support for students' concentration and focus, and its creating a bright, inviting, and comfortable atmosphere for both students and teachers. Teachers also mentioned the views of and interacting with nature and nature-mimicking interior elements encourages exploration and connecting students with nature and the world around them. The primary negative comment was that the views may be distracting for some students.

Parents were asked if they think that the incorporation of biophilic design elements (natural lighting, views of and access to the outdoors, nature-mimicking interior elements, etc.) has contributed to a positive learning environment for students. Eighty-eight percent of the respondents said yes, 8% said no, and 4% said that there were positive and negative aspects. By far the most common reason for positive responses was the natural light and views of nature, with parents mentioning their calming effect, mood-boosting and happiness promoting properties, support for students' concentration and focus, and its creating a healthy, beautiful, inspiring and welcoming atmosphere for students. The only negative comment was that the views may be distracting to some students.

Students responded to the survey at very high rates that they like the natural light, views to nature, and easy way-finding. Students responded in the interviews that the bright, happy colors and the windows' natural light and views to nature makes them feel better, more relaxed and less stressed. One student commented that she enjoys the transparency and beautiful views. "Every day when I'm walking through the halls it feels like I'm walking under trees when the sun comes through. There is a little reflection on the floors and I jump in the sunlight because I like playing in nature." Another student said, "One thing that makes me happy is how they made the cover for the windows look like leaves. It looks really cool to me." A technology and learning coach and a literacy coach said that they love the natural light, views to nature, the colors, and open floorplans, improving their attitudes and happiness, and think those are having a positive effect on students too, saying that they seem happy from all of their smiles. The literacy coach remarked that the windows were small and few in the old school, the change to the new school "really does make a difference." Students commented that the colors, interior biophilic patterns, natural light, and views to nature are "really relaxing" and "comfortable." Students also commented that they like the open floorplan, feeling calm and creative because of the ample space, and the small-group and individual spaces.

8. OVERALL PERFORMANCE

Grades two, three, four and five were tested in math and reading with South Carolina MAP (Measures of Academic Progress) testing. MAP testing compares student results year over year to measure growth (Figure 17 and 18). The four grades increased their math performance by an average of 15 and increased their reading performance by an average of 14.25. Grades two, three, and four exceeded their improvement goals and fifth grade exceeded its math goal and met its reading goal. BHES improved its SC Ready performance scores by 1.4% in English language arts and 0.6% in math. These improvements are in the context of the students in poverty percentage increasing from 45.3% in 2021-22 to 50.1% in 2022-23. The BHES Principal reported that "The academic performance improvement the first year in the new school was 'fantastic and highly motivating!' It is amazing that we met all and exceeded seven of eight

FIGURE 17

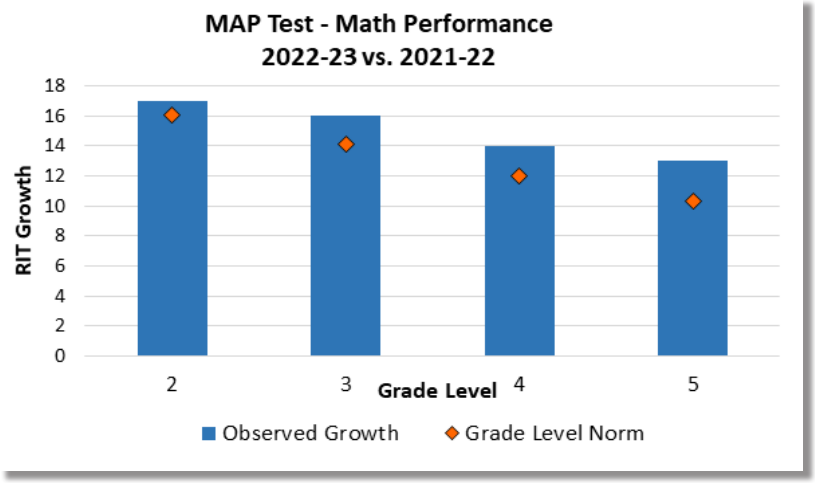
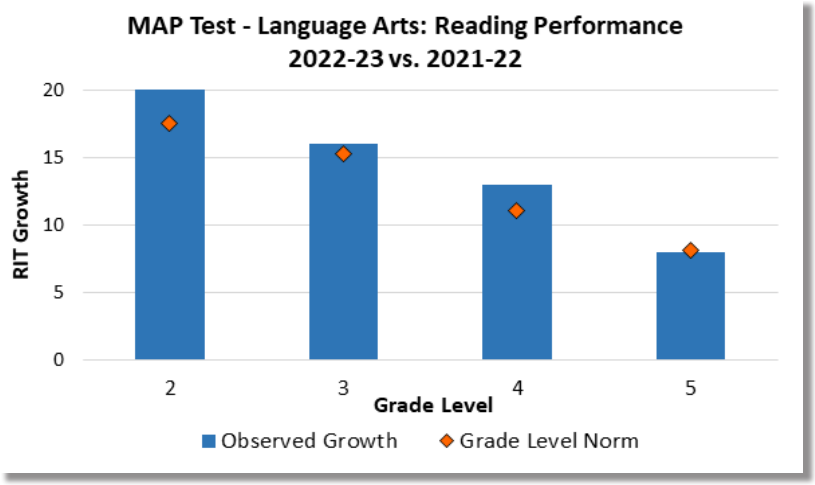


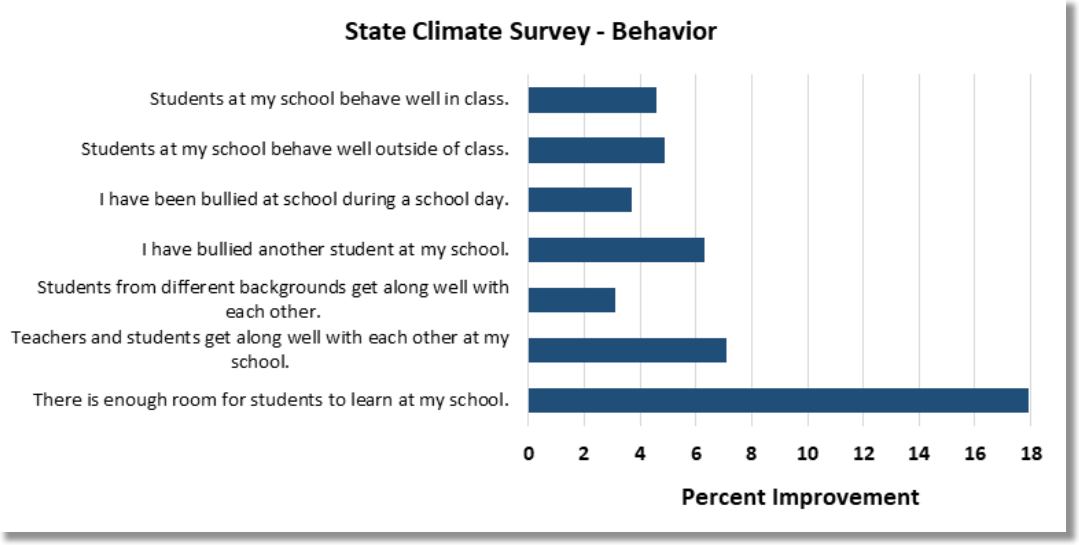
FIGURE 18



growth projections on MAP. In addition, the school improved its SC Ready performance scores by 2%. These are great accomplishments which we celebrate and are energized to continue."

The BHES Assistant Principal reported that "There's been a decrease in the overall number of referrals and the severity of the infractions. I think the sense of calm that's promoted throughout the building makes a difference. And I think it manifests in the behaviors that we do and do not see." Out of school suspensions went from 22 per year down to 17 per year. The school improved in every behavior-related South Carolina School Climate Survey measure, shown in Figure 19.

FIGURE 19



SC Dept. of Education reports that Chronic Absenteeism was 14% before COVID and 24.73% for the 2021-2022 school year. In the first year in the new school building, BHES tied for having the greatest reduction in the district in chronic absenteeism, from 17.3% to 12.3%.

Teacher retention rose 7.8% from 83.7% to 91.5%. BHES experienced among the highest increases in teacher retention of the 24 elementary schools in the district, and 10 times the increase in districtwide teacher retention which increased from 81.2 % to 81.9%. Teacher attendance increased from 93.4% to 94.4%. During interviews, one teacher stated, "I'm in my 28th year of teaching and this has been, by far, the best workspace I have ever been in."

VII. SUMMARY AND CONCLUSIONS

It is conclusive that CGD's inclusive approach to the BHES design, its safety features, and comprehensive integration of biophilic design features and student-centered learning spaces were successful in meeting the design goals. One School Board Member stated that "we accomplished everything we intended and more than we hoped."

State, district and school-level performance data (e.g. MAP and SC Ready assessments, and the SC Climate Survey) provided measures of the success of the combination of design approaches and features, and corresponding changes in teaching methods, in fostered improvements in standardized test scores, teacher retention rates, frequency and severity of disruptive behaviors, and chronic absenteeism.

Through the surveys, stakeholders reported an increased sense of safety, welcoming, belonging, and improved mental and emotional well-being. Survey results revealed a strong consensus among the stakeholder groups that the biophilic design elements significantly enhance the learning environment. These elements were identified as key contributors to the creation of more enriching and uplifting educational spaces, ultimately leading to improved academic performance and enhanced mental well-being.

Furthermore, stakeholders widely acknowledged the positive contributions of a diverse range of learning spaces. Teachers overwhelmingly reported that the student-centered design empowers them to innovate in their teaching practices. Students highlighted the benefits of flexibility and increased agency, noting a heightened sense of engagement and connection to their learning environment. Some teachers noted that while the design fosters a strong sense of community within grade levels, there is a decrease in the feeling of community across grade levels.

One lesson learned by CGD is that to increase the value of the facility as a teaching tool, more information about its design and use should be developed and shared with teachers, students and administrators. During the interviews, the architects explained reasons for some of the design elements and the teachers reported this information would be helpful to create lessons that bring attention to the elements and appreciation for their inclusion in the design.

VIII. FUTURE RESEARCH

It would be informative to conduct a follow-up assessment of school performance and stakeholder perceptions after additional use. If follow-up assessments are conducted, it

may be beneficial to study in more detail specific biophilic and student-centered learning elements, and developments in curriculum, pedagogy and school policies.

IX. ACKNOWLEDGEMENTS

We sincerely thank the CGD design team's architects, Scott Powell, AIA, Jim Determan, FAIA, and Ali McClure, AIA for their information on the design process and features of the school. We also sincerely thank the administrators in Richland School District Two and BHES who facilitated the surveys and interviews, and offered their perspectives on the design and design process, Will Anderson, RSD2 COO, Jennifer Coleman, Ph.D., RSD2 Director of Accountability, Research and Evaluation, and Shannon Holland, BHES Principal.

I. APPENDIX

Survey Results

Safety	Agree or Strongly Agree	Disagree or Strongly Disagree	# Responding
Students: I feel safe in my new school.	80%	20%	292
Teachers: The safety and security measures have helped to create a safe and secure learning environment.	82%	18%	45
Parents: I feel that my child(ren) is(are) safe in the new school.	95%	5%	37
Administrators: The safety measures have helped to create a safe and secure learning environment.	100%	0%	5

Feeling Welcomed and a Sense of Belonging	Agree or Strongly Agree	Disagree or Strongly Disagree	# Responding
Students: I like the new school building.	84%	16%	312
Students: I feel welcomed and included in the new school.	77%	23%	301
Teachers: Graphic displays of the school's history throughout the school promote a sense of community.	98%	2%	42
Parents: Our family likes the new school facilities.	100%	0%	41
Parents: I feel welcome in the new school.	100%	0%	34
Parents: I like seeing our school's history in the cafeteria and entry hall such as images and quotes by Ms. Hanberry.	100%	0%	38
Administrators: Graphic displays of the school's history throughout the school promote a sense of community.	100%	0%	5

Aggregated Measures (Weighted Average)	Agree or Strongly Agree	Disagree or Strongly Disagree
Students	80%	20%
Teachers	97%	3%
Parents	99%	1%
Administrators	100%	0%

Students and Teachers Feeling a Sense of Emotional Well-Being	Agree or Strongly Agree	Disagree or Strongly Disagree	# Responding
Students: In the new school building I get to move around more to stay active.	77%	23%	233
Teachers: The use of color in the school design has a positive effect on how I feel in the building.	95%	5%	44
Teachers: The colors in the school promote a positive learning environment for the students.	98%	2%	45
Teachers: The building design fosters a sense of wonder and curiosity.	98%	2%	45
Parents: The colors inside the school promote a feeling of well-being.	95%	5%	37
Parents: My child(ren) are happy in the new school.	100%	0%	37
Administrators: The use of color in the school design has a positive effect on how I feel in the building.	100%	0%	5
Administrators: The colors in the school promote a positive learning environment for the students.	100%	0%	5
Administrators: The window seat nooks in the main corridor support social-emotional learning.	100%	0%	5
Administrators: The building design fosters a sense of wonder and curiosity.	100%	0%	5

Aggregated Measures (Weighted Average)	Agree or Strongly Agree	Disagree or Strongly Disagree
Students	80%	20%
Teachers	95%	5%
Parents	91%	9%
Administrators	100%	0%

Facilitating Student-Centered Learning and Educational Best Practices Promoting Academic Achievement	Agree or Strongly Agree	Disagree or Strongly Disagree	# Responding
Students: My school building helps me learn.	76%	24%	301
Students: I like having a space outside of my classroom to work together with my classmates.	88%	12%	310
Students: I like the window seats in the hallway.	77%	23%	311
Students: I like spending time in the library.	73%	27%	271
Students: Being in this new school, I like having choices about how I learn (for example, by myself, in small groups, on projects).	79%	21%	296
Students: In the new school building there are more places to work together with my friends.	89%	11%	242
Students: In the new school building I get to move around more to stay active.	77%	23%	233
Teachers: The new school facilities help me innovate in my teaching.	98%	3%	40
Teachers: The new school facilities facilitate improvement(s) in student learning.	98%	2%	42
Teachers: Spaces and furnishings are adaptable and flexible.	85%	15%	40
Teachers: Spaces in the new building promote student-centered learning by supporting a range of teaching approaches (e.g. direct, indirect, experiential, independent and interactive).	100%	0%	47
Teachers: The new school design helps students use different spaces for various learning activities.	98%	2%	52
Teachers: The media center offers students with different learning styles a variety of ways to learn.	96%	4%	46

Teachers: The use of flexible seating in the classrooms (allowing students to work in different positions, postures, and configurations) contributes to a positive learning environment by supporting physical needs and promoting student engagement.	80%	20%	41
Teachers: The design of collaboration spaces (e.g. collaboration spaces outside classrooms, common spaces, group study rooms with visual connections to the classroom, media center) contribute to a positive learning environment.	96%	4%	45
Teachers: The window seat nooks in the main corridor support social-emotional learning.	85%	15%	33
Teachers: The building itself can be used as a teaching tool (e.g. creating lessons about colors, shapes, patterns, materials, design, structure and school history).	100%	0%	39
Teachers: Technology in the new school has a positive impact on how, when and where students learn.	100%	0%	47
Teachers: The school provides acoustic conditions that enable effective teaching and learning.	56%	44%	45
Parents: I feel that the new school has improved my child's learning experience.	91%	9%	33
Administrators: The new school facilities facilitate improvement(s) in student learning.	100%	0%	4
Administrators: Spaces and furnishings are adaptable and flexible.	100%	0%	5
Administrators: Spaces in the new building promote student-centered learning by supporting a range of teaching approaches (e.g. direct, indirect, experiential, independent and interactive).	100%	0%	5
Administrators: The new school design helps students use different spaces for various learning activities.	100%	0%	5
Administrators: The media center offers students with different learning styles a variety of ways to learn.	100%	0%	5
Administrators: The use of flexible seating in the classrooms (allowing students to work in different positions, postures, and configurations) contributes to a positive learning environment by supporting physical needs and promoting student engagement.	100%	0%	4
Administrators: The design of collaboration spaces (e.g. collaboration spaces outside classrooms, common spaces, group study rooms with visual connections to the classroom, media center) contribute to a positive learning environment.	100%	0%	5
Administrators: The window seat nooks in the main corridor support social-emotional learning.	100%	0%	4
Administrators: The building itself can be used as a teaching tool (e.g. creating lessons about colors, shapes, patterns, materials, design, structure and school history).	100%	0%	4
Administrators: Technology in the new school has a positive impact on how, when and where students learn.	100%	0%	4

Aggregated Measures (Weighted Average)	**Agree or Strongly Agree**	**Disagree or Strongly Disagree**
Students	80%	20%
Teachers	95%	5%
Parents	91%	9%
Administrators	100%	0%

Biophilic Design	Agree or Strongly Agree	Disagree or Strongly Disagree	# Responding
Students: I like the light coming from the outside into the school.	80%	20%	301
Students: I like being able to see plants and trees outside the windows.	75%	25%	304
Students: I like the playgrounds and outdoor areas.	91%	9%	306
Students: It is easy to find my way to where I need to go in the school.	86%	14%	303
Teachers: The natural lighting coming from the outside into the school contributes positively to my environment.	100%	0%	50
Teachers: The playgrounds and outdoor areas contribute to a positive student learning environment.	78%	22%	36
Teachers: The window seat nooks in the main corridor support social-emotional learning.	85%	15%	33
Teachers: The building design fosters a sense of wonder and curiosity.	98%	2%	45
Parents: I like the natural lighting coming from the outside into the school.	100%	0%	40
Parents: I like the way the new school feels connected to nature.	90%	10%	31
Administrators: The natural lighting coming from the outside into the school contributes positively to my environment.	100%	0%	5
Administrators: The playgrounds and outdoor areas contribute to a positive student learning environment.	100%	0%	3
Administrators: The window seat nooks in the main corridor support social-emotional learning.	100%	0%	4

Aggregated Measures (Weighted Average)	Agree or Strongly Agree	Disagree or Strongly Disagree
Students	80%	20%
Teachers	95%	5%
Parents	91%	9%
Administrators	100%	0%

Comfort	Agree or Strongly Agree	Disagree or Strongly Disagree	# Responding
Students: The temperature of my classroom is comfortable.	60%	40%	229
Students: The air smells fresh and pleasant in my classroom.	71%	29%	285
Teachers: The school temperature is comfortable.	83%	17%	46
Teachers: The air smells fresh and pleasant in the school.	100%	0%	46
Teachers: The school provides acoustic conditions that enable effective teaching and learning.	56%	44%	45
Administrators: The school temperature is comfortable.	100%	0%	2
Administrators: The air smells fresh and pleasant in the school.	100%	0%	4
Administrators: The school provides acoustic conditions that enable effective teaching and learning.	50%	50%	2

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