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THE IMPACT OF CLASSROOM DESIGN ON STUDENT LEARNING: A CASE STUDY OF CAMERON SCHOOLS

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ABSTRACT

Background: Students cannot be successful in terms of their behavior, or academic learning, without an environment that has been intentionally created for this purpose. Classroom design is a critical element in creating an effective learning environment. Classroom design should be intentional and purposeful, incorporating elements such as natural light, flexible spaces, comfortable furniture, strategic use of color, and technology that supports learning. The objective of this project is to discover how to enhance the learning environment for students in Cameroon by reviewing related work on how classroom design affect learning outcomes of students.

Method: This is a narrative review study in which peer-reviewed published research articles were reviewed. The articles were screened based on the title, abstract and full-text articles. 40 citations were screened of which 31 were excluded after the title and abstract were screened. 25 articles were then retrieved for reading and after reading through, 12 articles were found to be relevant to the critical review process of this study.

Result: Of all the design elements that make up the classroom, the environmental variables (temperature, acoustics, and lighting) have been the most studied individually. The SIN principles using the EB model; gives more indepth analysis and robust outcomes of the impact classroom design have on students' learning.

Conclusion: From literatures, it is anticipated that the built environment of the classrooms will have a great impact on students' academic performance, health and wellbeing. Therefore, imbibing these approaches before designing classrooms in Cameroon and understanding factors that influence student learning comfort; may go a long way to impact students learning outcomes.

INTRODUCTION

Education is a means to an end, the output of the educational system constitutes the nation's human as well as material resources. The skills and competences people acquire from schooling enable them to earn a living and participate in nation building. Thus, those who do not go to

school are deprived of the right of acquiring these skills and competences, which may hamper their social and economic growth and consequently the development of a nation. This is why the UN 1948 Universal Declaration of Human Rights, the 1994 Salamanca statements and the Cameroon 1998 law on the Orientation of Education were all aimed at providing educational opportunities to all[1].

Teaching and learning are multifaceted phenomena; and that's how we should be thinking about them, right from the start[2]. According to Mark Cohan[3], "Good students are those who learn. Whatever their preconceptions, barriers or deficits—whatever their story—they take new information and new experiences, and to the best of their ability, make them tools for transforming themselves and their world. Learning is a very complex process influenced by many factors[4,5,6]. Currently, there are significant differences in learning outcomes, activities, teaching methods and assessment across the sector. These have an effect on student engagement, learning and retention[7]. Generally, lecturers teaching with high student interaction and feedback are associated with higher student satisfaction ratings[8,9,7].

Students feel comfortable, confident, and successful when they know what is expected of them and can meet those expectations. These expectations combined with classroom routines, procedures, and organization create a positive classroom learning environment that increases students' ability to learn and be successful. In recent years, many schools and teachers have witnessed an increased prevalence of social and emotional needs as well as challenging student behaviors. Individually, these concerns cause problems for students as they develop their interpersonal and intrapersonal skills, while holistically, these concerns within the classroom can potentially disrupt learning. To mitigate these concerns, classrooms, schools, and districts have created plans for social and emotional learning, positive student behavior, and classroom and school-wide expectations, routines, and procedures. Collectively, these essential elements establish the strong foundation needed to create a positive learning environment that is welcoming for all students and safe for learning and discovery. Teachers get frustrated with a student's behavior when the structure within their classroom lacked the basic routines, procedures, and expectations needed to create a positive classroom environment in which the student could be successful. Students cannot be successful in terms of their behavior, or academic learning, without an environment that has been intentionally created for this purpose.

So how do teachers create a learning environment that is structured, organized, consistent, inviting, and engaging? Well, it is much easier than it sounds and hinges on the creation of a classroom environment prior to students arriving in the classroom. Creating a Positive Classroom Learning Environment include: Positive & welcoming atmosphere that is clean and minimalist, Establish clear routines and procedures, Consistent student expectations that meet the needs of all students, Organization is key—Everything has a place and everything in its place, Plan the routines and procedures for celebrating students and Quiet, private, and calm areas for personal time and reflection[10]. A well-designed classroom can facilitate engagement, promote creativity, foster collaborative learning, and improve academic achievement. By designing a classroom space that's optimised for student achievement, students can learn better, faster, and more readily than ever before.

Classroom design is a critical element in creating an effective learning environment. A well-designed classroom can enhance

engagement, promote creativity, foster collaborative learning, and improve academic achievement. Classroom design should be intentional and purposeful, incorporating elements such as natural light, flexible spaces, comfortable furniture, strategic use of color, and technology that supports learning. Research has shown that classroom design can have a significant impact on student behavior, emotions, and cognitive processes. As such, educators and school administrators should prioritize classroom design as a key component of their efforts to improve student learning outcomes. However, it is essential to note that effective classroom design is not a one-size-fits-all approach. Different classrooms and students have varying needs, and classroom design should be adapted to meet those needs. Classroom design should be based on an understanding of the learning goals, the needs of the students, and the teaching methods used in the classroom[11].

Classroom design is the process of planning, organising, and building an environment that maximises student achievement. Effective classroom design incorporates a range of different physical elements, including classroom layout, seating arrangements, lighting, acoustics, furniture, technology and colour, to ensure the best learning environment for students.

Much research has been conducted on the importance of classroom design on student learning. Evidence shows that physical design elements have the ability to influence student behaviour – for better or worse – which, in turn, affects learning, engagement, interaction, and concentration at school. A responsive case study held at Iowa State University revealed how classroom design influences student behaviour[12]. The case study explored the impact of a newly redesigned Active Learning Classroom (ALC) on students. The ALC utilised a number of design elements, including flexible furniture and portable whiteboards to promote a more active learning environment. The study demonstrated the many ways in which the physical attributes of your classroom design plan can promote student engagement. Mobile chairs can be used to encourage movement and facilitate interpersonal communication and collaboration, while portable whiteboards can empower group work and rapid assessment of knowledge. Removal of spatial barriers between teachers and students can also help promote a greater sense of connection between teachers and pupils, while a more flexible space makes classrooms highly adaptable to a variety of instructional strategies and approaches[12].

The physical space and layout of a classroom significantly impact the learning experience of students. A well-designed classroom should be spacious, flexible, and adaptable to various learning activities. For instance, classrooms that are designed to support collaborative learning activities should have flexible furniture such as tables and chairs that can be easily rearranged to facilitate group discussions. Additionally, the layout of the classroom should be organized in a way that minimizes distractions and disruptions, enabling students to focus on their learning activities. The use of color in classroom design can influence student behavior, emotions, and cognitive processes. Colors can evoke different emotions and feelings, and different colors can have different effects on learning. For instance, blue is often associated with calmness, while red is linked with excitement and stimulation. The color green has been found to improve reading ability, while the color red can help with memory retention. The use of color in classroom design should be intentional and purposeful. The furniture in a classroom plays an essential role in creating a comfortable and supportive learning environment. Classroom furniture

should be ergonomically designed, promoting good posture and reducing discomfort or fatigue. Additionally, furniture should be versatile and flexible, allowing for easy customization to fit different learning activities. Furniture should also be arranged in a way that supports learning activities, such as group discussions, presentations, and independent work. Technology has revolutionized classroom design, providing new opportunities for engagement and collaboration. Classroom design should incorporate technology that enhances student learning outcomes. For instance, interactive whiteboards can facilitate group work, while projectors can support multimedia presentations. Additionally, technology should be integrated in a way that supports student learning and allows for seamless transitions between different learning activities[10]. All of these changes can be made at minimal cost, proving that one really can design a classroom that maximises student achievement without digging too deeply into the school budget[11].

So what is the 'ideal classroom' design? The answer will vary greatly depending on the teaching style, the age of students, and even the subjects being taught, so one would need to consider the goals and teaching philosophies prior to designing a classroom. The perfect art room, for example, is unlikely to look the same as the perfect maths classroom design, as both rooms aim to achieve completely different goals. There are, however, some important elements that are common to many classroom styles.

Good natural light can help create a sense of physical and mental comfort which is conducive to student performance. An effective classroom design offers a large amount of natural light while cutting down on glare. Good quality artificial light will also be required to supplement classroom illumination when natural light is insufficient or unavailable. Natural light can improve mood and energy levels, leading to better engagement and focus. Classrooms should be designed with windows and skylights that allow for natural light to enter the space. Good quality artificial light will also be required to supplement classroom illumination when natural light is insufficient or unavailable. The elements in this category include: air quality, temperature, acoustics (sound or noise) and link to nature. The experiences of nature may offer profound benefits for students, potentially promoting social interaction, enhancing physical and cognitive development, encouraging imaginative play, and even stimulating empathy. While there are still a lot of questions about the impact of nature on childhood development, offering students views of nature, as well as doors leading directly towards a play area are believed to have positive effects on children. Including natural elements in the classroom, such as plants and wooden furniture, may also improve learning and behaviour. Poor air quality and ventilation can be a big problem in the classroom. A good classroom design incorporates windows with generous opening sizes, multiple ventilation points, and large rooms to prevent carbon dioxide buildup and stale air. Where natural ventilation is problematic, it's best to design a classroom that incorporates mechanical ventilation to improve air quality. The discomfort caused by an increase in temperature and humidity can see student achievement and task-performance deteriorate as attention spans decrease. That's why a cooler learning environment is best for supporting learning efficiency. Good central heating control allows teachers to maintain an optimal temperature in the classroom. Temperature can also be controlled by ensuring windows aren't directly facing the sun, or at least have some form of shading to prevent the temperature from

rising to uncomfortable levels. This is particularly important throughout Australia's harsh summer days. Controlling both internal and external noise can help ensure students are able to focus on their work, while allowing teachers to be heard. Situating rooms away from busy areas such as playgrounds and noisy roads is best, though buffers such as trees, shrubs, and other physical barriers can also be erected to help block external sources of sound. Internally, the best classroom design utilises sound absorbing elements, such as carpet and soft furniture, to improve acoustics. Chairs should also be fitted with rubber feet to minimise scraping, while seating can be arranged in a way that brings students closer to the teacher.

Individualisation accounts for roughly a quarter of classroom design's impact on student learning and behaviour. Elements include flexibility, ownership and connection. A flexible classroom offers opportunities for a range of different modes of learning. Long-term, a flexible classroom needs to accommodate changes in pedagogical goals, educational programs, and instructional strategies. Methods of building flexibility into your classroom include creating clear breakout zones, offering good and accessible storage options that don't take up useful learning space, as well as creating a varied floor plan for different activities, which is essential to younger pupils who need to engage in play-based learning. Large wall areas can also be used to display information, presentations, and student work, turning your room into a teaching tool in its own right. Physiological and psychological research indicates that a personalised space is important to developing a sense of self-worth, as well as to the formation of an individual's identity[11]. It's also argued that intimate and personalised spaces may be better for helping students absorb, memorise, and recall information. To help your students identify with 'their' classroom, try to create a distinctive room design that enables pupils to feel a sense of ownership over the space. Methods include displaying student work, and including elements that are personalised by the students themselves, such as coat pegs, lockers, or drawers with their names on it. Even choosing comfortable and interesting chairs and desks that are ergonomic to the student's specific age and size can help promote a sense of ownership. Connection involves pathways through the school environment which allow for safe and free movement. Wide corridors can help prevent overcrowding, and can also be used as storage areas to free up space within the classroom. Large pictures on the walls, landmarks, and abundant daylight with plenty of outdoor views can also be beneficial to your students as they navigate their way through the school.

As with individualisation, classroom design research has found that appropriate levels of stimulation account for roughly a quarter of room design's impact on learning. In the classroom, diversity of the floor layout, walls, and ceiling should stimulate the student's senses while still retaining a sense of order. Displays on walls should leave a minimum 20% of the wall uncovered so there's not too much visual noise. Interestingly, while younger students who need to engage in play-based learning performed better in classrooms with multiple learning 'zones', older students required a simpler arrangement with fewer zones in order to thrive. This means you'll need to consider the age of your students when determining the best floor plan for your classroom. Elements include colour, connection and complexity. Complexity refers to the visual 'busyness' of a space. Factors such as diversity, novelty, and atypicality can introduce visual complexity, which, in turn, affects a student's ability to learn and

focus. Research suggests a curvilinear correlation between complexity and student learning. This means that very high and very low levels of complexity create poorer learning conditions, while a middling level of visual complexity is optimal for student achievement. Colour has long been linked to productivity, with many studies suggesting that your choice of colours in the classroom can have a significant impact on behaviour, work performance, and mood. The Clever Classrooms report found a curvilinear link between colour and learning effectiveness. Overly bright colours such as orange or red could lead to overstimulation, while dull colours such as white resulted in understimulation. An effective way of striking the balance is to provide neutral coloured walls with a more brightly coloured feature wall. Additional elements such as blinds, desks, and chairs can then offer matching flashes of colour to invigorate the space, stimulate the mind, and bring together a cohesive colour palette[11].

American students average 11,700 hours of their lives in a school building from kindergarten to 12th grade[13], and college students typically spend at least another 400 classroom hours in post-secondary education buildings[14]. A growing body of scientific work has revealed the physical classroom environment's important—and sometimes surprising—effects onstudents' academic performance. Evidence demonstrates that classrooms' structural features (e.g., noise, lighting) and symbolic features (e.g., everyday objects that signal who belongs in the classroom) can facilitate or hinder student learning and achievement. In considering changes to classroom environments, policymakers may want to consider both the inadequate facilities of many U.S. schools, as well as the symbolic aspects that may prevent students from achieving their full potential.

According to the National Center for Education Statistics[15], more than half of U.S. public schools in 2012-2013 reported needing to spend money on their school buildings to bring them up to good condition. The most commonly reported structural inadequacies included windows, plumbing, and temperature regulation/ventilation. Schools that serve a higher concentration of children on free or reduced lunch were more likely to report structural inadequacies. Inadequate school facilities are related to worse test scores, even when taking into account (by statistically controlling for) the socioeconomic status and racial makeup of students[16,17,18,19]. One study did not find this relationship between structural condition and student performance in Wyoming[20]; however, a reason could be the way that structural conditions were assessed.

In Cameroon, many children attend primary basic education but fail to meet their basic learning needs[21]. These needs comprise both essential learning tools and the basic learning content required for them to be able to survive, to develop their full capacities, to live and work in dignity, to participate fully in development, to improve the quality of their lives, and to continue learning. These problems have led to major setbacks in basic education from the 1980s till present. The World Declaration on Education for All, Article 1, Paragraph 29, sets clearly the goals and strategies needed to establish a Framework for Action that is designed to enable all individuals to realise their rights to learn and fulfil their responsibility in order to contribute to the development of their society. Quality is at the heart of education, and what takes place in classrooms and other learning environments is fundamentally important to the well-being of children. Education for All is a basic human right at the heart of development[22].

It has been suggested that assessing the structural conditions with the educational purpose in mind is a better predictor of student performance than engineering assessments of structural quality[23]. Based on this, current narrative review is carried out to assess how classroom design can have impact on students' learning; with Cameroon in hind sight.

Method

This is a narrative review study in which peer-reviewed published research articles were reviewed. Google and Google Scholar were the database used for this work. The key search term includes classroom design, classroom and learning, learning in Cameroon.

The articles were screened based on the title, abstract and full-text articles. 40 citations were screened of which 31 were excluded after the title and abstract were screened. 25 articles were then retrieved for reading and after reading through, 12 articles were found to be relevant to the critical review process of this study.

Unpublished articles, editorials, letters to the editor, and commentaries were all excluded. A review on the impact that classroom design, building architecture and school facilities can have on students' learning was carried out.

RESULT

Of all the design elements that make up the classroom, the environmental variables (temperature, acoustics, and lighting) have been the most studied. Studies such as that of Choi, Van Merriënboer and Paas[24] found that temperature and air quality were the most important contextual determinants of learning. In terms of acoustics, it has been found that the farther from the sound source and the greater the presence of noise, the greater the negative impact on the learning process[25, 26]. Lighting has also been extensively studied for its involvement in physiological processes at the neurotransmitter level[27] and biological processes such as the regulation of circadian rhythms in humans[28]. For example, the presence of natural light has been identified as positively influencing reading and science activities[66,65]. In addition, the level of lighting affects cognitive performance depending on the difficulty of the task presented[29].

Another well-studied visual variable has been colour, because of its clear impact on students' emotions and functionality[24,30]. Authors such as Nancy Kwallek have shown that more errors are made in reading and writing tasks in white spaces compared to coloured spaces[31]. However, there seem to be inconsistencies as to which colours generate better performance. Some authors relate differences to the age of the students[30,32,33]. Others point to the importance of task content[34], whilst a third group highlights the role of arousal in this interaction[35,36].

It is important to refer to the dimensions and geometry of a classroom, which is undoubtedly the least studied aspect[37]. The lack of studies that concretely analyse this variable makes it difficult to take a clear position on its importance. However, among those that have been carried out, it has been shown that classrooms with high ceilings have an impact on learning as they negate the benefit of better lighting as well as increasing acoustic problems due to reverberation[38].

In all cases, it is noteworthy that each of the spatial elements is approached in isolation, offering results that are not very decisive, as they do not take into account the integrated set of variables that contribute to the characteristics of the space. For this reason, studies are needed to analyse how several design variables can affect the cognition of the individual, making it possible to detect those that have a greater effect on their behaviour. Some

studies have been based on contextualised points of interest through tasks of an attentional nature, with little consideration given to working memory, which is very much involved in the process of cognitive performance. Moreover, it is also important to note that research in this area does not pay much attention to the characteristics of the subject. The age of the subject is crucial given that learning is a continuous developmental process that varies over time[39]. Most studies focus on basic education at an early age, neglecting developments that may happen in higher education at the university level.

How the external context of a subject influences internal cognitive processes is a paradigm widely studied in the field of environmental psychology. Scientific analysis of aspects of spatial design in this field seeks to link two areas of knowledge that are apparently quite distinct: architecture, and educational psychology. Accepting the influence of external stimuli does not make the teacher's work less relevant, nor does it diminish examination of the students' internal perceptions. Rather, it serves to encourage a favourable outcome through the control of the physical variables of the given environment[6].

The completeness of school facilities and infrastructure is a supporting factor for the implementation of education[40]. Facilities and infrastructure in the classroom, such as spacious classrooms, air conditioners or fans, LCDs, blackboards or white boards, teacher desks, student desks, teacher chairs, student chairs, chalks, marker, boardmarker, air freshener, etc., play an important role in realizing continuity of learning process. Although not every facility and infrastructure must be available, but the completeness of these learning facilities will create the comfort of learning[41,56]. Learning comfort is a major factor in achieving success in learning. If learning conditions are comfortable, the learning process will be fun. As a result, student achievement increases[42,43].

Factors that cause students to be uncomfortable learning in class include: safety of classroom buildings including poor floor, wall, and ceiling conditions; availability and condition of chairs, desks in class, lack of vegetation around classrooms; and noise outside the classroom. Other discomfort is caused by an internet connection[45]that is still difficult to reach and textbooks are lacking. School conditions as described above includes the other side which is not fulfilled in criteria of comfort in student learning space. According to Widodo[46], student learning comfort can be realized with clean classrooms, good classroom lighting, comfortable room temperature (around 25º-28ºC), seating arrangement and ergonomics, use of instrumental music, low class noise levels, discipline classrooms, and structuring learning communities (student-teacher-parents) that support the learning process.

The thermal comfort of classrooms is an important issue for realizing the comfort of study rooms[47]. There are at least 4 categories of elements forming a comfortable study room[48]: elements forming the space, including: color selection of wall paint, carpet, ceiling; aesthetic element of space, for example putting up photos of president and vice president and national symbol, putting up the work of student, photographs of student's activities, pictures/posters that support the theme of learning, school rules, quotes, and verses from the holy books; furniture material elements, for example pieces of chairs and their appropriate size, shape of tables, paint tables and chairs; and arrangement of furniture that supports interpersonal communication. Scientific studies reveal the importance of classroom symbolic features, such as objects and wall

decorations in influencing student learning and achievement in the environment. This symbol as a form of information about their existence as valued students and included in the class[42].

Previous research on classrooms that proved to be most influential on student achievement was carried out by Barrett[32]. Three aspects of learning environment are emphasized as conceptual models in this study, include: naturalness, individualization, and stimulation (SIN). The method used is the EB (Environment-behavior) model. The results of the study found seven key classroom design parameters that influence student learning comfort including: light, temperature, air quality, ownership, flexibility, complexity, and color. Next, a study conducted by Kahya[49], showed that there was a mismatch between dimensions of classroom furniture and students' anthropometric measures in terms of: chair height, chair depth, and table height which had an impact on discomfort in classroom learning. Kumar, et al.[50] also examined the effect of thermal comfort on students. The results showed that students preferred the high airspeed range to restore comfort, either by opening windows and doors or by turning on ceiling fans. 80% use of ceiling fans at indoor air temperatures of 29 °C. In addition, scientific studies conducted by Cheryan, et al.[42], say that the structural facilities of buildings greatly influence learning. Inadequate lighting, noise, low air quality, and poor heating in the classroom are significantly associated with worse student performance.

Generally, the policy of schools (both public and private schools) on average; implements a full-day school system[51]. In the full day school system students are at school for approximately 8 hours every day which takes place around 7.00am to 4.00pm. Full day school system means the duration of learning time ranges from 8 to 12 hours of learning. Because of students spend more time in school, so they do not get bored easily the class should have a fun design, comfortable to learn, and not monotonous This is because the classroom is the element that most influences student progress and learning [52,53,41]. Because school facilities are complete, it will cause student satisfaction as the research results by Adedamola, et al.[52], students are satisfied with electricity supply, ceiling finishes, windows/doors and furniture in their classrooms. However, they were not satisfied with the provision of air conditioning and internet facilities in the classroom.

Based on these descriptions, long before designing school buildings, it is important to understand factors that influence student learning comfort. A comfortable and conducive classroom environment is the dream of every student. The learning comfort will be found when the learning environment is supportive.
Factors that influence student learning comfort include: air circulation factors, quietness, cleanliness, adequate & supportive facilities, and peer attendance. These factors are then grouped into two: factors originating from the physical environment (building & site themes and indoor space themes); and factors from within its occupants (human themes). The factor that shows the highest influence is the factor that comes from the physical conditions in the classroom (indoor space themes). Categories which make up each theme (from 3 big themes) interrelated with each other and can be controlled from various levels. Aspiration and lighting factors can be controlled at the building design stage, for example with natural double layer facade techniques for efficient energy consumption [54,55,56] and supported by space planning in class.

The quietness factor is influenced by the classroom environment which can be controlled by the physical design of school and also by its occupants. Furthermore, the

quietness and students' behavior on human themes are also influenced by the quality of physical conditions, including: the proportion of indoor space and occupants, space planning, cleanliness, and visual quality. Efforts to create comfortable learning continue to be improved. Various innovations and creativity are carried out, for example through playing instrumental music[57]; prepare certain types of classrooms and provide space for students to move freely (kinesphere)[55]; decorate classrooms, paintings, student work, schedules and school rules, state attributes, and sacred verses that can motivate students[48], provide adequate air circulation and lighting[32], provide natural ventilation through windows and doors classrooms or by using fans or air conditioners [50,58], as well as using lights and utilizing sunlight as lighting. It is important to note that each level of education has a different learning comfort[56,59].

Internal environment quality (IEQ) research has understandably focused on the readily measurable aspects of: heat, light, sound and air quality, and although impressive individual sense impacts have been identified, Kim and de Dear[60] argue strongly that there is no consensus as to the relative importance of IEQ factors for overall satisfaction. In parallel, a literature and area of practice has developed around "building performance" with a wide variety of typologies on offer [61,62]. The intelligence gained should feed forward into new designs, however, post-occupancy evaluations (POEs) are not commonplace and the lessons learnt are not generally available for use in practice[62]. In a recent benchmark for whole-life Building Performance Evaluation (BPE)[64] it is made clear that BPE aspires to objectivity using "actual performance of buildings [assessed through] established performance criteria …objective, quantifiable and measurable 'hard' data, as opposed to soft criteria (that is, qualitative and subjective. However, in practice this is difficult and hardly anywhere among researches have such evidence actually delivered.

But progress from this promising start still falls a long way short of comprehensively addressing the complexity of the design challenge. The difficulty of studying multiple dimensions is illustrated by the problems encountered when the impressive Heschong Mahone[65,66] daylighting studies extended to include other issues. The initial Heschong Mahone study[65] found children in classrooms with most daylighting and biggest windows progressed approximately 20% faster in maths and reading. The follow-up study [66] included thermal comfort, air quality, acoustic measures along with daylighting, but concluded the issue was more complex with daylighting having both positive and negative effects on learning. It is also evident in Tanner's struggle to analyse the multiple aspects impacting on learning rates in schools. His 2009 paper[68] is a second, more successful attempt, to more cleanly structure the possibly important design factors first mooted in his analysis in 2000[68].

So there exists an important research challenge around the issue of better understanding, and evidencing, the holistic impacts of spaces on users. The work described represents a radical exploration of a new direction. Rather than build up from the measurable dimensions of heat, light, sound and air quality, they took as a starting point the simple notion that the effect of the built environment on users is experienced via multiple sensory inputs in particular spaces, which are resolved in the users' brains.

These mental mechanisms can provide a basis for understanding the combined effects of sensory inputs on users of buildings at a level of resolution where "emergent properties"[69] may be evident. Until recently the only exemplar study using this sort of thinking was focused on

Alzheimer's care facilities[70]. The implication is that the broad structuring of the brain's functioning can be used to drive the selection and organisation of the environmental factors to be considered, not just their inherent measurability. Drawing from Roll's[71] detailed description of the brain's implicit systems, a novel organising model has been developed and proposed[72] that reflects: the human "hardwired" response to the availability of healthy, natural elements of our environments; our desire to be able to interact with spaces to address our individual preferences; and the various levels of stimulation appropriate to users engaged in different activities.

Within this structure the full range of relevant factors (e.g. light, layout, etc.) that might be elements of "good" design for a particular scenario (school) can be grouped, so providing a clear and balanced set of factors to be tested. These go well beyond the usual "big four". The utility of this approach depends, of course, on whether it allows clearer insights to be derived through practical research. The underpinning hypothesis is that students' academic progress will be dependent on a full range of factors drawn from across all three of the design principles.

The three dimensions, or design principles, have been used to suggest and structure the factors to be considered, namely: Naturalness: light, sound, temperature, air quality and links to nature; Individualisation: ownership, flexibility and connection and Stimulation (appropriate level of): complexity and colour.

The Naturalness principle relates to the environmental parameters that are required for physical comfort. These are light, sound, temperature, air quality and 'links to nature'. In particular there are specific requirements needed for children's learning environments. Each of the parameters has been individually researched. Natural light is known to regulate sleep/wake cycles[73] and what level of daylighting is optimum is still an area of active research. With regard to classroom acoustics Crandell and Smaldino[74] define the important metrics and Picard and Bradley[26] note that noise levels in classrooms are usually far in excess of optimal conditions for understanding speech. It has been shown that numerical and language test speeds increased when temperature was reduced slightly and ventilation rates were increased[75]. In their study Daisey et al[76] conclude that ventilation rates are inadequate in many schools and there is a risk to health. Research also suggests evidence of profound benefits of the experience of nature for children, owing to their greater mental plasticity and vulnerability[77,78].

The Individualisation principle relates to how well the classroom meets the needs of a particular group of students. It is made up of Ownership, Flexibility and Connection parameters. Ownership is the first element and is a measure of both how identifiable and personalized the room is. Flexibility is a measure of how the room addresses the need of a particular age group and any changing pedagogy. Connection is a measure of how readily the pupils can connect to the rest of the school. In this area there is a focus on how to make a personally optimized built environment that can benefit a pupil's learning process and behaviour. For example, it is argued that intimate and personalised spaces are better for absorbing, memorizing and recalling information[79]. When students feel ownership of the classroom, it appears the stage is set for cultivating feelings of responsibility[80]. Classrooms and hallways that feature the products of students' intellectual engagements representations of academic concepts, projects, displays, and construction are also found to promote greater participation and involvement in

the learning process [81]. Building Bulletin 99 (2006)[82] specified that the flexibility must be a key design requirement within the brief. Flexibility is needed to allow for different activities within the classroom and/or the needs of different users. The inclusion of Connection within Individualization is demonstrated by Tanner[67] and Zeisel et al[70] who emphasize that clearly marked pathways to activity areas improve utilization of space and performance metrics.

The Stimulation principle relates to how exciting and vibrant the classroom is. It has two parameters of Complexity and Colour. Colour is straightforward, but does encompass all the colour elements in the room. Complexity is a measure of how the different elements in the room combine to create a visually coherent and structured, or random and chaotic environment. It has been suggested that focused attention is crucially important for learning. Therefore, maintaining focused attention in classroom environments may be particularly challenging for young children because the visual features in the classroom may tax their still-developing and fragile ability to actively maintain task goals and ignore distractions[83]. Colour research shows room colour has an effect on both emotions and physiology causing mood swings that can have an impact on performance[84].

Clearly from literature it can be anticipated that the built environment of the classrooms will have a great impact on pupils' academic performance, health and wellbeing. However, how these aspects impact in combination has, up to now, been unclear. In other words how the sort of factors discussed above behave in the context of all of the others adds a level of complication that has confounded a clear view of the contribution of the physical space despite all of the atomised evidence. Thus, the Education Endowment Foundation in its well respected reviews of factors influencing pupil learning concluded in 2014 that: "changes to the physical environment of schools are unlikely to have a direct effect on learning beyond the extremes."[85].

The HEAD Project seeks to bridge the gulf between what is a high level of confidence in the literature about some of the different elements, and a lack of convincing evidence concerning their combined effects in practice. The findings on the individual parameters were taken and compared with existing evidence from the literatures. Many of the sources used have been focused on single factors, quite often in controlled conditions, whereas this findings derive from a "natural inquiry" where focused on one factor, while still acting in the context of all the others. Although informed by previous studies, this study goes on to further concentrate on the complex interaction of a range of built environmental factors on pupils in primary schools. That said, findings concerning comfort issues, rooted in the design principle of 'naturalness', are found to be generally consistent with other literature. Light, temperature and air quality have a significant impact on the pupils' learning outcomes. However, this study also finds that large window size is not universally valuable in terms of maximizing learning benefits. Orientation, shading control (inside and outside), the size and position of openings, all have to be carefully taken into consideration so that the risks of glare, overheating and poor air quality can be avoided at the design stage. Furthermore, the importance of occupants' control of the 'naturalness' is evident. High quality and quantity of electrical lighting, central heating with thermostatic control and mechanical ventilation can all give opportunities for teachers/pupils to adjust the environment to a more comfortable level. It should be noted that although acoustics and links to nature displayed correlations to learning progress in the bivariate analysis, they were competed out correlated significantly with pupil progress. Multi-level regression modelling

was then used (including pupil factors) and resulted in seven key design parameters being identified that best predict the pupils' progress. These were Light, Temperature, Air Quality, Ownership, Flexibility, Complexity and Colour.

The impact of the modelled classroom parameters was 16% of the total range of the variability in pupils' learning progress. Inclusion of three very different local authority areas with distinctly differing pupil intake characteristics and differing school building environments intended to support the analysis at the school level; did not do so. It became evident that the variability in learning progress to be explained at the school level in the multilevel model was only 3%. Including this level of analysis did not enhance the overall analysis and so was dropped.

An "Environment-Behaviour factors model" was built drawing on the available literature[70], but also informed by preparatory surveys of pupils[88], teachers [86] and post-occupancy evaluations of schools [89]. The E-B model was also structured by the main three "design principles", namely naturalness, individualisation and stimulation. Each of these was then broken down into "design parameters", of which there are ten in total, and these in turn were expanded into eighteen more detailed "indicators". These were then underpinned by thirty more detailed, measurable, "factors".

Overall Progress was the dependent variable in regression analysis, which had been grand mean centred over all 3766 pupils. In total there were 669 pupils (18%) rated as Special Education Need SEN, 874 children (23%) with English as an Additional Language EAL, and 775 pupils (21%) with Free School Meal FSM status. Some children were excluded from the study based on the exclusion criteria eg students who were absent from school the whole year.

Correlations of Overall Progress for each pupil against environmental measures showed all ten parameters were positively correlated with progress. Of the five Naturalness parameters Light has the highest correlation with Overall progress. In the formulation of the Light parameter the highest quantity of natural and electrical light, but without direct sunlight, was found to be optimum. Too much direct sunlight into the classroom was found to cause a glare problem. In the Individualization theme all three parameters were found to be significantly positively correlated. For the Level of Stimulation parameters the two factors of Complexity and Colour were both found to be curvilinear and an intermediate level of the parameter was found to be optimum. For example both high Complexity and low Complexity classrooms scored poorly, while intermediate values of Complexity scored highly.

Results from the two-level model show the Level 1 factors that were significant in the model were Weighted Start, Weighted Start-on-age, FSM, EAL and SEN. Gender was not significant in the model. Children on FSM, and who have SEN did significantly worse than other pupils. EAL pupils did significantly better. The sizes of the coefficients is indicative of their relative effect, with EAL pupils and FSM having similar sized effect and the SEN pupil Overall Progress deficit being more than three times as great. With Weighted Start the model coefficient is negative indicating pupils who are in higher year groups made less progress. It should be noted that although the NC points scale is linear and there is an expectation that each pupil, whatever their age, makes the expected two sub levels improvement per year, there is an acknowledgement by teachers that learning rates in children are not linear. For Weighted start-on-age the model coefficient is positive indicating pupils who are advanced for their age group did on an average make more progress.

These results are similar to the earlier bivariate correlation analysis, but now of course provide an interactive backdrop within the same model as the environmental factors, to which we now turn. In addition to these operationalised pupil factors, other aspects linked to the pupils, but not measured, are also included in the modelling, within the unexplained variation compartmented at the pupil level.

A study in Cameroon sought to examine if the curriculum, infrastructures and teachers' attitudes may influence school exclusion amongst disabled pupils. Three hypotheses were formulated based on the three variables: curriculum (teaching programmes), infrastructures and teachers' attitudes. 150 public primary school personnel from 12 primary schools in Yaounde, Mfoundi IV Sub-Division of the Centre Region of Cameroon were involved in this survey. A questionnaire was used for data collection. Both descriptive and inferential statistics were used to analyse the data. The results show that there was a significant impact of curriculum and teachers' attitudes on inclusive classroom but there was no significant impact with respect to the infrastructure variable. Considering that infrastructure variables have no impact, it was still recommend that good quality and relevant infrastructure be put in place and also teachers' programme and training be revised to enhance the pedagogic skills that may include handing individual pupils' differences in inclusive classrooms[90].

DISCUSSION

The objective of this project is to research on how the learning environment for students in Cameroon can be enhanced by reviewing related work on how classroom design affect learning outcomes of students, thereby contributing to the achievement of the Cameroonian government's policy goals of reducing disparities across regions and improving the quality of primary education. The outputs of this work will give insight to the importance of planning the constructions of classrooms and other building facilities ; including and the provisions of desks, chairs, fans and windows in creating a design that will facilitate good learning and learning environment in Cameroon schools.

Improved educational environment is believed to help boost students' academic performance, and the constructions of other facilities like sanitary toilet facilities and provision of equipment like fans; will aso have positive impacts on the students' health and hygienic conditions. Thus, the effectiveness and impact of the teaching is high[91]. In the course of carrying out this research, it was discovered that no research has been done in Cameroon using the principles of SIN or its elements to establish the current state of learning in schools. The work done by Tomoyuki[91] revealed the high impact of teaching due to the presence of infrastructure while that carried out by [90] revealed that there was no significant impact of infrastructure on school exclusion of special needs pupils. These outcomes did not adopt the principle of SIN and therefore, do not reflect the impact of classroom design in Cameroon schools. Studies have substantiated that a whole range of professional quality and other school related factors, are associated with high learning achievement. School systems work with pupils, and carry significant social trust for transmitting values, inspiration and knowledge to improve the future society[92]. Although significant efforts have been made to improve educational quality in primary schools in Cameroon, it must be confessed that learning conditions for teachers and pupils have not been the best. In terms of school facilities, a lot more needs to be done. According to Holt[93]; a system-wide transformation is crucial for the attainment

and sustainability of improved educational quality[93] .

This study has thrown light on a variety of issues ranging from broad conceptual challenges, to quite specific, practical questions. One of the major, more general, contributions of this study is to confirm the hypothesised utility of the naturalness, individuality, stimulation SIN conceptual model as a vehicle to organise and study the full range of sensory impacts experienced by an individual occupying a given space. That this might be a productive way forward was argued speculatively in 2010[72], but the results obtained provide clear evidence that each of these dimensions appears to have a role in understanding the holistic human experience of built spaces. It is interesting that (in this particular case of primary schools) the naturalness factors account for around 50% of the impact on learning, with individuality and appropriate level of stimulation factors accounting for roughly a quarter each. It could not be predicted if each of the dimensions would remain in play and if so with what relative weight. We now at least have an initial indication, in one situation. The finding that the combined impact of the built environment factors on learning scales at explaining 16% of the variation in learning progress made is a major finding in an area where, as Baker and Berstein phrase it[94]: "the relationship between school buildings and student health and learning is more viscerally understood than logically proven". This is of course relevant in relation to schools as primary schools provide a relatively simple situation to study a complex general problem. By extension the results suggest that the scale of the impact of building design on human performance and wellbeing can be identified and that it is non-trivial. It has also been informative how some factors that display quite strong and significant correlations, as single factors, with learning progress, drop out of the analysis when combined with all other factors, for example "links to nature".

CONCLUSION

The classroom's comfort level primarily depends on various factors, including air circulation, noise level, cleanliness, the availability of suitable facilities, and student attendance. These factors can be categorized into two groups: those related to the physical environment (building and site conditions, indoor space conditions) and those related to the occupants (human factors). Among these, the physical conditions within the classroom, particularly indoor space conditions, have the most significant influence.

Elements like lighting, color, and classroom dimensions are crucial when designing educational spaces, and they can also apply to virtual learning environments, which are becoming increasingly prevalent. Educational reform often focuses on improving the quality of education to ensure that students acquire essential skills. Creating a pleasant learning environment can inspire students to attend school enthusiastically and achieve academic success. Effective classroom design should be purposeful, fostering engagement, creativity, collaboration, and academic achievement. Prioritizing classroom design can lead to enhanced learning outcomes and a positive, supportive learning atmosphere.

Implementing these approaches when designing classrooms in Cameroon and understanding the factors that affect student comfort could greatly impact learning outcomes.

Strengths, Limitations, and Recommendations:

The chosen focus and research approach have paved the way for future studies with

increased confidence. The study concentrated on primary schools in the UK/England and explored formal academic progress. However, the impact of whole-building conditions may differ in other contexts. Future research could benefit from a more in-depth qualitative and focused quantitative approach, utilizing triangulated methods.

Within the existing dataset, further sub-analyses are possible, and the broader SIN conceptual model, linked to MLM, offers potential insights into the holistic effects of classrooms on student learning. It's crucial to build on this promising start and develop these concepts and techniques further.

Future studies could expand to different types of educational institutions, including secondary schools and universities, and even extend beyond education to offices, elderly care facilities, and retail spaces.

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