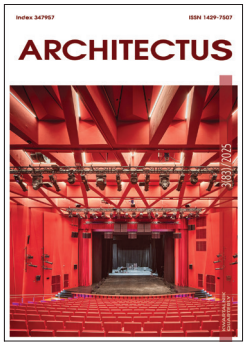

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Research through colour-based design: Supporting the learning and well-being of children with autism

Abstract

Planning an educational environment dedicated to children with autism presents a significant challenge for designers. The appropriate colour arrangement of classroom interiors can influence, shape, and control their behaviour, activities, learning processes, skill development, and acquisition of experiences. Furthermore, it can enhance the effectiveness and productivity of their actions. It may also contribute to ensuring protection and safety, as well as comfort and well-being in the spaces where children spend their daily lives. Numerous studies emphasize that the colours of educational environments have physiological, emotional, and cognitive effects on students, which is particularly relevant when designing interiors for educational institutions dedicated to children with cognitive disorders. Appropriate colours can have a significant impact on their interaction with the environment, which is often limited or impaired. The aim of the present study was to explore and expand the scientific foundations for the selection of colour schemes in educational environments designed for children with neurodevelopmental disorders, including children with autism spectrum disorder (ASD). The research process employs a literature review method, analyzing and reviewing scientific sources related to the application of colours in educational spaces and environments dedicated to individuals with autism. Additionally, the study utilizes survey methodology and the "Research Through Design" approach, integrating design activities into the research process. A crucial source of knowledge is the stimulus material created by the designers, which facilitates the acquisition of new insights into the needs, preferences, and expectations of autistic children in their educational environment.

Key words: architecture, research through design, colour perception, autism-friendly classroom, well-being in learning spaces

Introduction

Ergonomic interior design ensures human health, physical condition, mental well-being, and social interactions. A crucial aspect of interior design is analyzing and controlling the psycho-physical effects of a given space on its users. The interior environment can influence moods, behaviours, activities, productivity, and overall well-being. A specific interior can have either a positive or negative impact on its users; therefore, it is essential to examine the factors that may benefit specific users in particular spaces. Interior design involves selecting and arranging various elements such as forms, lines, divisions, textures, colours, and lighting. Among these, colours hold special significance as they define spatial diversity, help differentiate individual elements, highlight different zones, emphasize divisions, and create a specific mood, climate, and atmosphere within the space. Properly planning a colour-based design concept is crucial, especially when the users of a given space include individuals with special needs, such as those with cognitive impairments (Nair et al. 2022). Findings from previous studies suggest that scientists and designers should pay more attention to the interiors where autistic children and individuals with psychological disorders reside, including those with cognitive processing difficulties. Aisha Issa Al-Badrani and Reham A. Sanad (2022) emphasize that appropriate colours can significantly influence their interaction with the environment, which is often limited or impaired.

Designing an educational environment for children with autism presents a major challenge for designers. A well-structured

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classroom interior can shape, influence, and regulate their behaviour, activities, learning processes, skill development, and experience acquisition. Moreover, it can enhance the efficiency and productivity of their actions while contributing to their sense of security, comfort, and well-being in their daily environment. Architectural design that takes into account the sensory needs of individuals with autism significantly impacts concentration, community functioning skills, and the educational effectiveness of children. Such environments can positively influence behaviour by enabling children with autism to better develop skills and acquire experiences while simultaneously fostering a sense of comfort and safety. Factors such as the sensory quality of the environment, its intelligibility, and predictability are critical for designing spaces tailored to the needs of children with ASD. Scientific literature consistently indicates that the design of a well-organized, safe, and stimulating classroom interior is essential for supporting the development, learning, and overall well-being of children with autism (Tola et al. 2021).

The design of facilities and interiors intended for individuals with autism requires specialized knowledge from designers. As such, classroom design, particularly colour planning should be rooted in both psychological theory and empirical user feedback. However, many design decisions in educational interiors are still based on intuition or generalized aesthetic preferences rather than direct input from neurodivergent users. This gap has prompted a growing interest in participatory and user-informed research methods. Understanding how children with ASD perceive and respond to different colour palettes is essential for formulating design strategies that enhance their comfort, focus, and inclusion.

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by differences in communication, behaviour, and sensory processing. Individuals with autism spectrum disorder, including those with Asperger's syndrome, frequently experience significant difficulties with sensory processing. These challenges typically manifest as hypersensitivity (i.e., overstimulation) and hyposensitivity (i.e., understimulation). Hypersensitivity refers to an increased sensitivity to sensory stimuli, where an excessive influx of sensory input can become overwhelming, potentially leading to stress, anxiety, or behavioural disturbances. In contrast, hyposensitivity denotes a reduced sensory responsiveness, wherein insufficient visual or other sensory stimulation may result in social withdrawal, diminished interaction, and decreased cognitive alertness. Individuals with ASD often display either hyper- or hypo-sensitivities to sensory inputs such as light, sound, and colour. In classroom settings, these sensitivities can significantly affect a student's ability to concentrate, interact, and learn. Given this, the design of educational environments should not only accommodate these differences but actively support students in achieving optimal cognitive and emotional functioning. In educational settings, where children with autism spend significant time, thoughtful colour selection can improve emotional regulation, reduce overstimulation, and support learning. Conversely, the wrong colour choices may lead to sensory overload, emotional distress, or disengagement (Ben-Sasson et al. 2009).

This research aims to explore how children with ASD respond to colour in educational spaces by combining theoretical literature with empirical investigation. Specifically, the study integrates academic findings with a school-based colour preference survey to identify which colour palettes align with sensory comfort and perceived well-being. Rather than focusing solely on functional performance, this project adopts a phenomenological lens, seeking to understand how spatial experience, perception, and emotional resonance intersect in colour-related design choices. Additionally, this study raises important questions: Do children with autism prefer muted or vibrant colour palettes? Are there universal colour strategies that can accommodate both autistic and neurotypical users? Can controlled contrasts or moderate complexity be beneficial in certain sensory profiles? By addressing these questions, the study aims to inform inclusive and responsive design strategies for autism-supportive classrooms.

The following research questions were formulated:

– What types of interior colour palettes are most preferred by children with Autism Spectrum Disorder in learning environments?

– How do these preferences correspond with commonly recommended colour guidelines for ASD-friendly spaces?

– Can visual preference surveys inform evidence-based design strategies for autism-supportive educational interiors?

The findings of studies can directly serve as guidelines for designers, helping to improve the overall functioning of autistic children in society.

The impact of interior colours on autistic children and individuals with psychological disorders

Many studies have attempted to decipher the physiological and psychological effects of colours observed in children with autism. Numerous behavioural changes are attributed to the colours present in their immediate surroundings. Colours can also influence emotions and determine learning outcomes. Autistic children are highly sensitive to colours, which affects their perception. Most of them perceive colours with greater intensity. Therefore, colours used in interior spaces influence their mood, behavior, activity, learning, and development, making careful selection essential (Franklin et al. 2008). Both an environment that lacks stimulation and one that is overly stimulating can be detrimental to students. Classrooms should be visually engaging to stimulate the learning process and improve the behaviour of students with ASD. Some studies suggest that neutral colours are essential to prevent overstimulation, while others argue that white and bright work-spaces reduce efficiency and cause anxiety. So far, no definitive formula has been established for the optimal use of colours in classrooms. However, the strong impact of colour and its key role in designing educational spaces for autistic children is widely emphasized (Gaines et al. 2014).

The chosen colour scheme in interiors must account for visual sensitivity, which is of utmost importance for autistic children with sensory processing disorders, as it can influence their mood, learning ability, and overall functioning

(Nair et al. 2022). It is crucial to emphasize the impact of colours and the importance of using colour therapy to support autistic children, allowing them to function without discomfort in a calming environment while also correcting behavioural irregularities (Altenmüller-Lewis 2017; Ghazali, Sakip and Samsuddin 2018).

Positive effects of appropriate colour choices

Analysis of colour preferences among autistic children has shown that pastel, matte, and muted hues are the most suitable, as they do not distract and have a calming effect (Nair et al. 2022). The use of neutral and uncomplicated colour palettes is recommended (Black et al. 2022). Implementing autism-friendly colour schemes such as pastel, neutral, and subdued shades can create soothing sensory experiences within interiors (Altenmüller-Lewis 2017). Some researchers suggest using light, soft, natural tones of off-white and pale pink, emphasizing that the choice should depend on the functional level of autistic children and their sensory sensitivities (Tola et al. 2021). The use of neutral and relaxing tones derived from natural and organic materials is considered appropriate for autism-friendly educational environments, as such colours foster learning, increase concentration and attention, and enhance energy levels (Altenmüller-Lewis 2017). Research recommends the use of pastel, neutral, and calming colours with low arousal properties, as well as the incorporation of natural materials for walls, floors, and ceilings (Ghazali, Sakip and Samsuddin 2018). Observational studies indicate that students with autism prefer gentle and natural colours, such as blue and green, among which light blue is identified as the most appropriate colour for classrooms (Black et al. 2022). Research conducted by Sardar S. Shareef and Guita Farivarsadri (2019) confirms that the use of grey, green, blue, and white in classroom environments has positive effects on students with autism.

Problematic colour combinations and their negative impact

Unfavourable and undesirable colours (including overly dark shades) and poorly perceived colour combinations can cause extreme behavioural changes, such as agitation, irritability, disorientation, anxiety, anger, and aggression (Nair et al. 2022). Most researchers strongly emphasize the need to limit strong colour contrasts (Tola et al. 2021). They indicate that overly stimulating, arousing colours should be avoided, as they can cause distress and irritation. Bright colours are not recommended (Ghazali, Sakip and Samsuddin 2018). It is advised to refrain from using bold and overly bright colours, as they may overstimulate and disrupt a sense of calm, potentially causing autistic children to become tense and aggressive (Altenmüller-Lewis 2017). Psychological effects have been linked to specific colours. Red and yellow can be problematic as they may cause anxiety, distress, or confusion in autistic children, leading them to withdraw (Altenmüller-Lewis 2017). The harmful impact of red and yellow has been observed by over 70% of teachers working with autistic children. Additionally, patterns in interior spaces should be used sparingly, as excessive visual complexity may negatively impact autistic individuals (Black et al. 2022).

Individual colour preferences and aversions

Autistic children may have specific preferences and aversions to colours, which are associated with complex emotional connections to certain colours. Their visual perception of colours can influence their emotions and behaviour (Ludlow et al. 2014). The observed aversion to yellow may indicate a hypersensitivity in children with ASD. Psychologists suggest that yellow is one of the most visually fatiguing colours. Its perception may be overwhelming for children with ASD, whose sensitivity to sensory stimuli is heightened. ASD children are often hypersensitive to tactile, auditory, and visual stimuli, including colour perception. Their advanced visual discrimination abilities can make yellow an overstimulating sensory trigger, leading to sensory overload. As a result, they may naturally avoid such a strong stimulus as an aversive reaction. This avoidance may manifest in unusual colour preferences observed in autistic children (Grandgeorge, Masataka 2016). Studies also confirm that colour preferences and obsessions in autistic children can be linked to their favourite objects, leading to a higher-than-usual preference for specific colours. This is an area that requires further research, as findings could be valuable for developing teaching methods for autistic children, such as colour-based learning associations (Ludlow et al. 2014).

Design and educational strategies in the context of the use of colours in interiors

Colour therapy plays a crucial role in helping autistic children function comfortably and correct behavioural irregularities. Proper design elements can contribute to an autism-friendly environment. Best practices include avoiding bright, highly saturated colours, as the perception of intense hues can vary significantly among autistic individuals. Their application should be limited to minimal elements, such as way-finding maps and visual signage. It is also recommended to minimize dramatic contrasts. To create a soothing sensory experience, it is recommended to use a palette of pastel, neutral, and subdued colours. Research suggests that shades of blue and green are preferred, while yellow may trigger aversion due to its potentially overstimulating effect (as it can be perceived as too intense). Gradual colour transitions and the use of soft complementary gradients are recommended, with contrast restricted to functional purposes, such as functional zoning. Colour can be used to define spatial boundaries and establish relationships between different areas. It can also assist in dividing spaces into distinct zones without the need for physical barriers. Additionally, colours can facilitate navigation by incorporating fluid, uniform colour pathways on the floor or subtle colour contrasts along edges, which visually anchor the autistic user within the space (Mohamed, Almaz 2024). Observations indicate that the use of colour-coded markers in interior spaces for clear functional zoning and highlighting certain elements can make spaces more accessible and easier to navigate for

autistic children (Altenmüller-Lewis 2017; Ghazali, Sakip and Samsuddin 2018; Tola et al. 2021). Environments with different sensory stimulation levels can be associated with colours that offer varying degrees of stimulation. Personalizing spaces with individual colours or objects may help autistic children create stronger associations with their surroundings (Ghazali, Sakip and Samsuddin 2018).

To enhance architectural students' and designers' understanding of the emotional impact of colours on autistic children, realistic research and testing must be conducted among autistic and psychiatrically diagnosed children. Accurate and comprehensive findings regarding their colour preferences may guide the selection of appropriate colours for their interior environments. Studies are needed to determine the influence of colours on learning and the completion of specific, complex tasks. Research should also explore the psychological impact and its effect on cognitive function development in autistic children (Al-Badrani, Sanad 2022).

Scientists also emphasize the importance of active engagement and participation from parents, caregivers, teachers, and young designers in research and intervention activities to better understand autistic children's behaviour. This involvement is essential for productive experiments, testing, and initiatives aimed at improving developmental, behavioural, and educational outcomes for autistic children (Fearns et al. 2022).

Detailed observations could contribute to the development of architectural design strategies that support growth, facilitate social interaction, and improve integration within various facilities, including educational institutions. Awareness and understanding of the specific needs, preferences, challenges, and expectations of autistic children will enable architects and interior designers to incorporate these essential psychological and physiological aspects, including colour perception, when designing ergonomic, inclusive, and supportive spaces for children on the autism spectrum (Altenmüller-Lewis 2017; Fabri, Satterfield 2019).

The importance and effects of colours in the educational environment

The colour design of educational environments determines how supportive and stimulating these spaces are for learning and daily life. It should facilitate identification and well-being, support individual and social development processes, and enhance pedagogical approaches and activities. Colour concepts for educational institutions should be developed to ensure that colours and materials align with the following fundamental themes:

– familiarity with the environment and a sense of security,
– effective communication,
– stimulation, differentiation, and heightened perception,
– motivation,
– attention and concentration,
– relaxation,
– movement,
– creativity.

The prevailing atmosphere of an educational environment should be characterized by openness. It should foster a sense of security and trust while radiating friendliness and accessibility (Meerwein, Rodeck and Mahnke 2007). A classroom is a shared space for teachers and students, where most of the school day is spent. It is a place for learning, working, communicating, and collaborating. The atmosphere should promote a sense of security and support concentration (Meerwein, Rodeck and Mahnke 2007). The design of classroom interiors as educational spaces is considered one of the most decisive factors influencing students' behaviour and academic performance. The choice of colours in classrooms is crucial in creating an effective learning environment. It is evident that colour is not merely an aesthetic element but plays a significant and influential role in shaping the relationship between users and their educational environment. Based on empirical evidence, it has been concluded that colour balance in classrooms is essential to support learning processes. Both excessive and insufficient stimulation can have negative consequences (Gaines et al. 2014). This chapter highlights blue as a positive physical and psychological stimulus in educational spaces, recognizing it as one of the key design factors.

Numerous studies have examined the emotional effects of warm and cool colours and their influence on users' perception. The findings provide insights into which colour ranges and specific hues are most effective in educational environments, shaping students' perception and behaviour. Research indicates that cool colours evoke feelings of relaxation, tranquility, spaciousness, comfort, security, peace, and harmony. Additionally, it has been confirmed that people feel more introverted in cool-coloured environments, which can enhance their focus on visual and cognitive tasks. A study analyzing students' perception of colour in a classroom environment found that the use of different colours in the classroom interior had a statistically significant impact on students' perceptual performance. The results demonstrated that blue-coloured spaces were perceived more positively, being described as joyful, spacious, calm, pleasant, quiet, and comfortable compared to spaces in other colours. Therefore, it is recommended to incorporate shades of blue to enhance comfort conditions, improve the quality of the educational environment, and create an effective learning space for students (Yildirim, Cagatay and Ayalp 2015).

There is evidence that the colours of architectural environments have physiological, emotional, and cognitive effects on students. The latest research findings indicate that classrooms with cool, low-saturation wall colours (e.g., light blue) are perceived more positively by school-aged students compared to classrooms with warm, low-saturation wall colours (e.g., cream or pink). Studies also confirm that cool colours enhance student concentration, and shades of blue are particularly beneficial for completing difficult tasks and achieving higher IQ test scores. Both psychological and neurophysiological findings suggest that cool tones improve attention and memory performance more effectively than warm tones. This can be explained at the neurophysiological level as the effect of an optimal activation level of the sympathetic nervous system, which supports higher alertness and cognitive efficiency. Grow-

ing evidence suggests that the colour of classroom walls influences student performance. Research results indicate that cool-toned colours increase stimulation and improve performance in tasks related to attention and memory; these findings can serve as a foundation for developing design guidelines (Llinares et al. 2021). Based on previous studies, it is possible to track findings regarding the impact of colours on learning, cognitive task performance, and creativity. These insights are valuable in supporting the ergonomic design of educational environments.

Most studies in this field have focused on two of the three primary colours, i.e., red versus blue. A word association test confirmed that people generate different associations with red compared to blue in the domain of cognitive tasks. It has been shown that red and blue activate different motivations, which in turn enhance performance in different types of cognitive tasks.

Red, due to its association with danger and mistakes (e.g., red-marked errors, stop signs, and warning signals), is expected to trigger avoidance motivation, which has been shown to increase alertness and risk aversion. As a result, red should improve performance in detail-oriented tasks (i.e., tasks requiring focused, careful attention) compared to blue.

Conversely, blue has positive associations in the natural world (e.g., the sky, water oceans, seas) and is commonly linked to openness, calmness, and tranquility. It is likely to activate approach motivation, as these associations signal a safe and welcoming environment, encouraging individuals to adopt innovative rather than conventional problem-solving strategies. Indeed, studies on approach motivation have shown that people behave in a more exploratory and even risk-taking manner under the influence of blue. Associated with openness and freedom, blue can activate a promotion-focused mindset, encouraging individuals to strive for positive outcomes, which in turn enhances performance in creative tasks. Thus, blue, in contrast to red, is more beneficial for tasks that require creativity and imagination. The avoidance motivation triggered by red leads to lower performance as it suppresses attempts to answer more complex questions. The positive effect of blue on creativity should be recognized and utilized (Mehta, Zhu 2009; Elliot, Maier, 2014).

Another study examining the impact of colour on cognitive task performance not only considered task type but also task difficulty. The study investigated the effects of three environmental colours red, blue, and grey on two types of cognitive tasks (detail-oriented tasks and creative tasks) at two difficulty levels (simple or difficult). The findings showed that red improved performance in simple detail-oriented tasks. Meanwhile, blue improved performance in difficult detail-oriented tasks as well as in creative tasks, regardless of whether the task was simple or difficult. This research highlights the critical role of blue in educational environments (Xia et al. 2016). Blue is perceived as a motivator for intellectual and logical thinking, supporting clarity of thought and enhancing concentration, which is why its use is recommended in classrooms and learning spaces. It has a positive effect on students' perception, instilling a sense of hope, curiosity, and satisfaction within a group. Some studies even suggest that blue has an awakening effect on students, increasing their performance in educational environments (Baper, Husein and Salim 2021). Some research confirms that colour serves as a cue that helps students recall information. For example, blue increases the likelihood that transmitted information will be remembered. Therefore, using it in educational settings can support knowledge retention (Chang, Xu and Watt 2018). Other studies analyze the perception of blue as a crucial factor in educational environments, positively influencing students' emotions and moods, which is particularly relevant in designing interior spaces for children with cognitive disorders. The classroom atmosphere can impact children's emotions, helping them calm down and focus on learning. Blue is often associated with peace, tranquility, and harmony, as it creates a calming effect in the environment, making it an ideal colour for a peaceful and soothing classroom setting.

This calming, relaxing effect fosters positive emotions and promotes children's rest. It may even have healing properties, which is why it is frequently used in pediatric hospital rooms. Studies show that children feel more relaxed and at ease in cool-coloured environments, such as light blue, especially in medical facilities (Thung, Ahmad 2022).

Analyzing the connection between colours, emotions, and cognitive learning, it is crucial to emphasize that positive emotions triggered by colours can improve cognitive and affective performance. Understanding how colours influence students' emotions, moods, and behaviors is valuable for designers. As a cool and passive colour, blue should be used to maintain a sense of calm among students, fostering positive emotions that enhance knowledge acquisition. It has been confirmed that blue classroom walls provide the highest level of relaxation and comfort (Chang, Xu and Watt 2018; Liu et al. 2022). This positive effect of blue can be confirmed by the ecological theory of colour preference, which suggests that an individual's preference for a particular colour is influenced by their positive associations with objects and entities related to that colour. As a result, this theory predicts (and research supports) that people tend to favour colours that remind them of objects they like (e.g., saturated blue, often associated with positive elements such as clear skies and clean water). One of the potentially significant factors influencing colour preferences is symbolic associations and abstract conceptual connections. Blue is often described as a calming colour because it reminds us of the ocean and the sky. For children, object-based associations (e.g., the sea or a lake being linked to blue) are more relevant than symbolic associations (e.g., associating blue with peace) (Schloss, Palmer 2017). Common colour preference patterns in a population may indicate either "hardwired" preferences established over evolutionary timescales or individual, flexible preferences shaped through shared exposure to common stimuli that evoke similar emotions for example, the pleasure of seeing a clear, blue sky might be as widespread today as it was millennia ago. Any resulting preference for blue may thus have both contemporary and ancient roots (Best 2017; Hurlbert, Ling 2012).

The scientific interest in the relationship between colour and psychological functioning can be traced back to the German poet and polymath Johann Wolfgang von Goethe.

In his classic work "Theory of Colours" (1840), Goethe proposed intuitive speculations on how colour perception influences emotional experience. These speculations were later expanded upon in the 20th century by psychiatrist Kurt Goldstein. Goldstein integrated Goethe's ideas with his clinical observations, suggesting that colour perception triggers physiological responses in the body, which manifest in emotions, cognitive concentration, and motor behaviours. Based on these studies, blue was recognized as a relaxing colour, promoting introspection and eliciting calm and stable reactions. This state, induced by blue, was found to positively impact cognitive task performance, making it easier to complete complex tasks (Elliot, Maier 2014).

Research objectives, materials, and methods

This study aimed to expand the scientific foundations for selecting colours in educational environments designed for children with autism spectrum disorder. Throughout the research process, a literature review method was employed, analyzing and examining scientific sources related to the application of colours in educational spaces, particularly those designed for individuals with autism. Additionally, a survey methodology and the "Research Through Design" approach were applied, integrating design activities into the research process. A crucial source of knowledge was the stimulus material created by the designer, which enabled the acquisition of new insights into the needs, preferences, and expectations of autistic children in their educational environment.

Before conducting the study, the research process was consulted with the Research Ethics Committee at Wrocław University of Science and Technology. It was determined that, despite the sensitivity of the group of children involved in the study, the applied method was entirely safe as it did not interfere with, harm, or exhaust the children, and it respected their needs, limitations, and disabilities.

The conducted study was associated with the modernization of classroom interiors in a school for children with autism spectrum disorder (Horyzont Primary School in Żory). To create an environment that positively influences children's behaviour, emotions, and learning outcomes, it was necessary to examine the scientific foundations for selecting colours in educational settings and to identify the colour preferences of autistic children and children with Asperger's syndrome. To achieve this, the study aimed to determine which colours were most liked and desired by these children in their immediate surroundings, as well as which colours were recommended due to their positive impact. The study reviewed existing research findings in this field and surveyed a primary school for children with autism and Asperger's syndrome. A total of 44 children, aged 8 to 14, participated in the study (all diagnosed with neurodevelopmental disorders). They were shown various colour scheme concepts for children's rooms, allowing them to choose the one they would most like to live in. The idea of the children's room in the first stage of the study was based on its role and significance in the child's daily life, as a space with which they have the closest contact and in which they perform all their activities. It is also a space that serves an educational function from the earliest moments of the child's life, even before the preschool and school stages. Afterward, a survey was conducted regarding their favourite colour. This sequence of actions was intentional by observing various colour combinations in interior spaces, the children could recall colours more effectively, making it easier for them to select their preferred colour. Based on the results of the study, it was determined that blue was the most favoured colour among autistic children.

In subsequent stages of the research process, the study aimed to determine which colours were recommended in educational settings. A literature review on the impact of colours on emotions, moods, behaviours, effectiveness, and productivity in the learning process regardless of students' psychophysical condition allowed for the conclusion that blue is the most recommended colour for educational environments. This led to a suggestion and hypothesis, which the study sought to verify: that planning school interiors using the colour blue could be a universal approach. By ensuring a generally positive influence on students, this strategy could also accommodate the special needs and expectations of autistic children. Taking into account autistic children's preference for the colour blue and its significant role in educational spaces, a design concept for a classroom interior in a school for children with autism spectrum disorder was developed. Among these design concepts, 12 variations were created, featuring different shades and combinations of blue. Additionally, one concept was developed without the colour blue, instead incorporating a monochromatic palette of light, warm, and muted shades such as beige, yellow, orange, salmon-pink, and light brown. Accent nuances within this palette included light grey, black, muted red, and a honey-toned wood shade. The children studying in this classroom (every child participated in the first stage of the study) were presented with all 13 design concepts and were asked to choose the one they liked the most.

Research process

The first stage of the research experiment involved assessing which colours were most liked and preferred by autistic children. To achieve this, a set of stimulus materials was prepared, consisting of visual representations of children's rooms designed in various colour schemes. These visualizations were created by students in the Faculty of Architecture at Wrocław University of Science and Technology as part of the "Interior Design" course. The children's room concepts were printed on high-quality paper to ensure easy and effective presentation to the children. The survey was conducted at Horyzont School in Żory, a primary school for children with autism spectrum disorder. The school follows the national curriculum for primary education (grades 1–8) in accordance with the guidelines of the Ministry of National Education (MEN) and implements individualized therapeutic programs. Currently, the school educates 56 children. As part of the survey, 44 children aged 8 to 14 were examined by presenting them with various colour concepts for children's rooms, allowing them to choose the one in which they would most like to live. The

children's room concept that received the highest preference is presented in Figure 1.

In the next stage of the test, a survey was conducted to determine the preferred colour as each child selected a crayon in their favourite shade. The sequence of these activities was deliberate: by viewing visual representations of children's rooms, the children were exposed to various colour combinations in interior spaces. This process helped them recall colours more effectively and make a more informed choice. The visual stimulation played a key role in facilitating their selection of a preferred colour. Based on the study results, shades of blue emerged as the most favoured among autistic children. A summary of the colour preference results is presented in Table 1.

Based on literature studies, the results of the conducted research, and an on-site inspection, design guidelines were developed for the colour concept of one of the classrooms at Horyzont Primary School for Children on the Autism Spectrum in Żory. Materials from the on-site inspection are presented in Figure 2.

Design Guidelines for the Classroom Modernization Concept in Terms of Colour Selection, Considering the Need to Create an Autism-Friendly Educational Environment.

Based on literature studies:

– Use of pastel, neutral, and muted colour palettes.

– Minimization of bright, intense, and highly saturated colours (limited to small elements or visual markers).

– Reduction of strong contrasts, including highly contrasting patterns.

– Application of blue shades based on the colour preferences of autistic children.

– Use of blue shades due to their positive impact on autistic children.

– Implementation of blue shades for their beneficial effects on students in an educational environment (influencing behaviour, mood, and learning outcomes).

– Use of gradual colour and tonal transitions.

– Application of complementary (opposite) colours in soft, muted, subdued gradients/shades.

Fig. 1. The concept of a children's room was the most popular among autistic children (visualization by M. Sobeczko, M. Ciesielska)

Il. 1. Koncepcja pokoju dziecięcego, który cieszył się największą popularnością wśród dzieci autystycznych (wizualizacja: M. Sobeczko, M. Ciesielska)

Table 1. Children's favourite colours based on their choice of crayon (but in different shades) (elaborated by A. Jaglarz)

Tabela 1. Barwy preferowane przez dzieci na podstawie wyboru kredki w ulubionym kolorze (o różnych odcieniach) (oprac. A. Jaglarz)

Colour	Number of preferences
Blue	12
Red	8
Green	6
Light brown/ocher	5
Pink	5
Black	5
Purple	2
Yellow	1
Total	44

Fig. 2. Existing condition of the classroom at Horyzont Primary School for Children on the Autism Spectrum in Żory: (photo by A. Jaglarz)

Il. 2. Stan istniejący klasy w Szkole Podstawowej Horyzont dla dzieci ze spektrum autyzmu w Żorach: (fot. A. Jaglarz)

– Use of more pronounced contrasts for functional purposes, such as zoning, emphasizing key elements, defining boundaries and divisions, and establishing relationships between different areas.

Based on the conducted research experiment/survey:

– Use of shades of blue (including navy blue) based on the selected concept of the children's room.

– Use of shades of blue based on the colour of the crayon chosen by the children.

– Use of shades of blue as colours associated with a galactic, cosmic, and celestial style and design.

Based on the on-site inspection:

– Use of colours matching the existing floor finish (sand-coloured ceramic tiles with pink and blue accents).

– Suggestion to change the floor finish and introduce a different colour scheme.

– Incorporation of the burgundy colour of the existing window joinery into the proposed colour scheme.

– Use of the existing colour scheme of the technical installation/ventilation (steel-coloured spiro pipes).

– Suggestion to paint the technical elements in a different colour.

– Retention of the current wood colour in the proposed palette (with the option to replace or renovate the current furniture).

– Changing the wall colour (white is considered inappropriate in an educational environment as it reflects light, distracts the eye, causes discomfort when looking, and interferes with concentration and learning).

Taking into account the design assumptions, various colour concepts for the school classroom were developed. From these, 12 concepts were selected that most closely matched the design guidelines derived from literature studies, survey results, and site inspection. Additionally, one extra concept was included, featuring a monochromatic palette without any blue shades. This alternative palette consisted of light, warm, and subdued shades of beige, yellow, orange, salmon-pink, and light brown. Accent nuances in this palette included light gray, black, subdued red, and a honey shade of wood. All 13 concepts were presented to students of the modernized classroom as part of a homeroom lesson (Table 2 presents the 13 colour concepts for the classroom along with a description of the colour palette used.) The homeroom teacher asked the students to choose their preferred concept. Surprisingly, the unanimous choice was the concept that did not include the colour blue at all.

Results and discussion

The findings from previous scientific studies confirm the positive effects of blue on the moods and behaviours of autistic children. Similarly, researchers consider blue to be the most beneficial colour in educational environments, as it effectively supports students' learning and cognitive processes. The colour preference survey conducted among autistic children at Horyzont Primary School also identified blue as their most favoured colour. However, the children's final selection of a classroom design concept that does not include the colour blue was unexpected and surprising. Figure 3 illustrate the final design concept of the school classroom, featuring a colour composition tailored to the needs, requirements, and expectations of children with autism and Asperger's syndrome.

When comparing the selected classroom design concept (Fig. 3) with the previously chosen children's room concept (Fig. 1) and analyzing the colour schemes used, a notable similarity emerges in terms of yellowish shades, light browns, and black elements. The deep navy blue present in

Table 2. Colour concepts for the classroom at Horyzont Primary School for Children on the Autism Spectrum in Żory (elaborated by A. Jaglarz and B. Turgut)
Tabela 2. Koncepcje kolorystyczne klasy w Szkole Podstawowej Horyzont dla dzieci ze spektrum autyzmu w Żorach (oprac. A. Jaglarz i B. Turgut)

No.	Visualization of the colour concept	The colour palette used
1		**Triadic colour palette:** Yellow, blue, red (three colours located at equal distances from each other on the colour wheel) **Main colours:** Yellow and blue (walls and large surfaces) **Accent colours:** Golden brown of wood, beige pink, various shades of blue (colours emphasizing, enhancing and accentuating the main colours based on harmony, selected based on the similarity of shades and similarity of colours to the main colours) **Contrasting colour:** Red (appearing on details and exposing the main colours based on contrast, the most eye-catching colour) **Contrasts:** Brightness contrast (dark shades, e.g., dark blue against light shades: light yellow, white), complementary contrast (yellow vs. blue), saturation contrast (saturated red and muted beige-pink light shade), tonal contrast (is based on a combination of three primary colours – red, blue and yellow), temperature contrast (warm shades, e.g., yellow or red vs. cool tones – shades of blue), quantitative contrast (yellow and blue vs. red, contrasting colour patterns on the floor relative to the smooth surfaces of the walls and ceiling)

No.	Visualization of the colour concept	The colour palette used
2		**Complementary colour palette:** Yellow and blue (colours located on opposite sides of the colour wheel) **Main colours:** Warm yellow and beige (walls, large surfaces) **Accent colours:** Shades of blue, shades of beige, light brown and white (furniture, details) **Contrasting colour:** Intense yellow **Contrasts:** brightness contrast (deep navy vs. yellow, white), saturation contrast (saturated yellow and muted yellow), complementary contrast (yellow and blue), temperature contrast (warm yellow vs. cool blue)
3		**Complementary colour palette:** Yellow and blue **Main colours:** Deep blue and light beige (walls, large areas) **Accent colours:** Shades of blue, beige yellow, shades of grey, white **Contrasting colour:** None (the colour scheme is based on the complementary contrast of yellow and blue) **Contrasts:** Brightness contrast (deep navy and light beige, white), complementary contrast (yellow and blue), temperature contrast (warm shades of beige and yellow against cool shades of blue and grey)
4		**Triadic colour palette:** Blue, yellow and red **Main colours:** Blue and beige yellow (large areas) **Accent colours:** Shades of blue and gray, light brown wood, muted, light, pinkish shades of red **Contrasting colour:** None (no colour dominates, the scheme is harmonious due to the equal proportions of shades of three complementary colours) **Contrasts:** Brightness contrast (dark blue against light yellow and white, dark red against white), complementary contrast (blue and yellow), tonal contrast (is based on a combination of three primary colours – red, blue and yellow), temperature contrast (warm red/yellow vs. cool blue)
5		**Triadic colour palette:** Blue, yellow, pink **Main colours:** soft blue and beige (walls, surfaces) **Accent colours:** Shades of blue, shades of pink, light brown wood, white **Contrasting colour:** None (harmonious complementary scheme) **Contrasts:** Complementary contrast (blue and light yellow), temperature contrast (cool blue vs. warm pink/yellow)
6		**Complementary colour palette:** Pink and blue **Main colours:** Soft pink and beige, blue (walls, large areas) **Accent colours:** Light blue, shades of pink, white, light brown wood **Contrasting colour:** None (harmonious complementary scheme) **Contrasts:** Temperature contrast (warm pink/light brown wood vs. cool blue)

Table 2 cont. Colour concepts for the classroom at Horyzont Primary School for Children on the Autism Spectrum in Żory (elaborated by A. Jaglarz and B. Turgut)
Tabela 2 cd. Koncepcje kolorystyczne klasy w Szkole Podstawowej Horyzont dla dzieci ze spektrum autyzmu w Żorach (oprac. A. Jaglarz, B. Turgut)

No.	Visualization of the colour concept	The colour palette used
7		**Complementary colour palette:** Orange and blue **Main colours:** Warm coral and blue (walls, dominant surfaces) **Accent colours:** Light pink and white, shades of blue **Contrasting colour:** None (as blue and coral provide the main complementary contrast) **Contrasts:** Saturation contrast (rich coral against subdued pink and beige), temperature contrast (warm coral contrasts with cool blue)
8		**Triadic colour palette:** Yellow, blue and red **Main colours:** Deep blue and light yellow **Accent colours:** shades of blue, gray, white, pink, yellow and light brown wood **Contrasting colour:** Red (appearing on details and exposing the main colours on the basis of contrast, the colour that catches the eye the most) **Contrasts:** Brightness contrast (deep blue vs. light yellow), saturation contrast (saturated red against muted light pink), tonal contrast (is based on a combination of three primary colours – red, blue and yellow), temperature contrast (warm yellow/red vs. cool blue), quantitative contrast (yellow and blue vs. red, contrasting colour divisions/patterns on the floor relative to the smooth surfaces of the walls and ceiling)
9		**Triadic colour palette:** Yellow, blue and red **Main colours:** Deep blue and light yellow (walls, large surfaces) **Accent colours:** Shades of blue, shades of yellow, light brown wood, light pink, white, grey **Contrasting colour:** Red (appearing on details and exposing the main colours on the basis of contrast, the colour that catches the eye the most) **Contrasts:** Brightness contrast (deep blue vs. light yellow), saturation contrast (saturated red against a diluted light pink, saturated yellow against a light, subtle yellow), tonal contrast (is based on a combination of three primary colours – red, blue and yellow), temperature contrast (warm yellow/red vs. cool blue), quantitative contrast (yellow and blue vs. red, contrasting colour divisions/patterns on the floor relative to the smooth surfaces of the walls and ceiling)
10		**Triadic colour palette:** Yellow, blue and red **Main colours:** Deep blue and light yellow/beige (walls, large surfaces) **Accent colours:** shades of blue, pink, light shade of wood **Contrasting colour:** Red (appearing on details and exposing the main colours on the basis of contrast, the colour that catches the eye the most) **Contrasts:** Brightness contrast (deep blue vs. yellow), saturation contrast (saturated red against light pink, saturated blue against light blue), tonal contrast (is based on a combination of three primary colours – red, blue and yellow), temperature contrast (warm yellow/red contrasts with cool blue), quantitative contrast (yellow and blue dominate, red used in smaller accents)

No.	Visualization of the colour concept	The colour palette used
11		**Triadic colour palette:** Blue, yellow, red **Main colours:** deep blue and light yellow/white (walls, large surfaces) **Accent colours:** Light brown wood, shades of grey, shades of blue **Contrasting colour:** Red (appearing on details and exposing the main colours on the basis of contrast, the colour that catches the eye the most) **Contrasts:** Brightness contrast (deep blue vs. yellow/white), saturation contrast (saturated blue against muted grey-blue), tonal contrast (is based on a combination of three primary colours – red, blue and yellow), temperature contrast (warm red/yellow vs. cool blue), quantitative contrast (blue and yellow dominate, red used strategically, contrasting colour divisions/patterns on the floor relative to the smooth surfaces of the walls and ceiling)
12		**Complementary colour palette:** Blue and golden brown/yellow **Main colours:** Blue and off-white (walls, largest spaces) **Accent colours:** Warm wooden tones, brown, orange, muted red, shades of yellow **Contrasting colour:** Saturated yellow **Contrasts:** brightness contrast (light walls vs. deep blue elements), saturation contrast (saturated blue vs. light muted blue), temperature contrast (cool blue contrasts with warm wooden and yellow), quantitative contrast (blue surfaces vs. yellow elements)
13		**Analogous colour palette:** Beige, apricot yellow, golden orange, light brown (closely related colours in the colour wheel) **Main colours:** Light beige and soft apricot yellow (walls, largest surfaces) **Accent colours:** Brown, muted red, grey (shade similarity and colour similarity in relation to the main colour) **Contrasting colour:** Black **Contrasts:** Brightness contrast (light yellow vs. black), quantitative contrast (black is used in small details but strongly stands out), saturation contrast (the black is deep and intense compared to the remaining shades), temperature contrast (warm yellow and apricot tones contrasted with cooler grey and black)

the selected children's room design, typically categorized as a shade of blue, was likely perceived by the children as nearly black especially since its darkness was accentuated by the contrast with white.

Interpretation of contradictory findings on colour preferences

While blue was the most selected crayon colour, the preferred interior concept excluded blue altogether. This contradiction may result from several factors. Firstly, children may associate blue as a favourite in isolation (e.g., crayons) but perceive it differently when integrated into larger, immersive spatial contexts. Secondly, the dominant yellow-beige palette in the selected design might have evoked a warmer, safer, more "home-like" feeling, aligning with sensory comfort rather than abstract preference. Thirdly, visual complexity, lighting, or contrast levels in the visualizations may have influenced children's perception subconsciously, overriding their previously stated preferences. This highlights the fact that favourite colours in abstract do not always translate into preferred spatial environments, especially in neurodiverse children. It suggests that emotional comfort and perceived warmth in interior design can override isolated colour preferences. This divergence underscores the complexity of design decisions for neurodiverse users and emphasizes the importance of testing spatial experience rather than relying on isolated colour preferences.

Comparative synthesis of literature and empirical findings

While the literature widely supports the use of blue as a calming and cognitively supportive colour, this study reveals that autistic children may prefer non-blue environments when spatial, emotional, and sensory aspects are collectively

Fig. 3. The classroom design concept selected by children with autism (visualization by B. Turgut)

Il. 3. Koncepcja projektowa sali lekcyjnej wybrana przez dzieci z autyzmem (wizualizacja: B. Turgut)

considered. This suggests a divergence between abstract preferences and holistic environmental perception. Designers should thus avoid rigid generalizations based on isolated colour studies and instead adopt a flexible, context-sensitive approach informed by real user engagement. Therefore, interior design strategies for autism-supportive environments should integrate both abstract colour preferences and experiential spatial perceptions, ensuring a balance between theoretical guidelines and real-world emotional responses.

Conclusions

The results of this study provide valuable insights that can serve as guidelines for architects and interior designers when planning educational spaces for autistic children. When designing the colours of educational spaces dedicated to autistic children, it is advisable to consider:

– the use of monochromatic or analogous colour schemes, in which there are shades of one colour or closely related colours that are adjacent on the colour wheel,
– the preference for warm colour tones,
– the application of light, pastel colours,
– the avoidance of highly saturated colours in favour of muted and subdued shades,
– the minimization of strong colour contrasts,
– the incorporation of neutral or monochromatic shades, such as black, grey, white, or deep navy, to introduce subtle emphasis or complementary elements in the overall colour composition.

Due to certain discrepancies in the results of previous studies, there remains a need to analyze and test the impact of various colour schemes on psychological, behavioural, and task-related outcomes among children with cognitive disorders, such as autism or Asperger's syndrome. Designing interiors with appropriate colour combinations may also support children with other neurological conditions, including ADHD, hyperactivity, or attention deficits. The prevalence of these disorders has increased over the past century, underscoring the necessity of improving interior spaces to accommodate the special needs of children, with the aim of facilitating their preparation for and fostering healthy interactions with the community. It is also important to emphasize that modifying colour schemes in the indoor environments of educational institutions catering to children with autism and other neurodevelopmental disorders potentially enhancing their psychological, behavioural, and task-related patterns often involves relatively simple adjustments that require minimal effort and cost (Attia 2020).

In justifying the aims and significance of the conducted research, it is essential to underscore its applicability within professional practice for architects and interior designers, offering them concrete design directives. Moreover, the obtained findings can serve as a valuable pedagogical resource and a theoretical framework for students and academic faculty engaged in architectural design education.

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Streszczenie

Badania poprzez projektowanie kolorystyczne: wspieranie uczenia się i dobrostanu dzieci ze spektrum autyzmu

Planowanie środowiska edukacyjnego dla dzieci z autyzmem stanowi istotne wyzwanie dla projektantów. Odpowiednia aranżacja kolorystyczna wnętrz sal lekcyjnych może wpływać na ich zachowanie, aktywność, procesy uczenia się, rozwój umiejętności oraz zdobywanie doświadczeń. Ponadto może zwiększać skuteczność i efektywność ich działań, a także przyczyniać się do zapewnienia ochrony, bezpieczeństwa, komfortu i dobrostanu w prze-

strzeniach, w których dzieci spędzają czas. Autorzy wielu badań podkreślają, że kolory środowiska edukacyjnego wywierają fizjologiczny, emocjonalny i poznawczy wpływ na uczniów, co jest szczególnie istotne w kontekście projektowania wnętrz instytucji edukacyjnych przeznaczonych dla dzieci z zaburzeniami poznawczymi. Odpowiednio dobrane kolory mogą znacząco wpływać na ich interakcje ze środowiskiem, które często są ograniczone lub zaburzone. Celem niniejszego badania było zgłębienie i uzupełnienie naukowych podstaw doboru kolorystyki w środowiskach edukacyjnych przeznaczonych dla dzieci z zaburzeniami neurorozwojowymi, w tym dzieci ze spektrum autyzmu. Proces badawczy opierał się na metodzie przeglądu literatury – analizie i ocenie źródeł naukowych dotyczących zastosowania kolorów w przestrzeniach edukacyjnych dla osób z autyzmem. Ponadto wykorzystano ankiety oraz podejście „research through design", integrujące działania projektowe z procesem badawczym. Istotnym źródłem wiedzy był materiał stymulujący, stworzony przez projektantów, który umożliwił zdobycie nowych informacji na temat potrzeb, preferencji i oczekiwań dzieci autystycznych w kontekście ich środowiska edukacyjnego.

Słowa kluczowe: architektura, percepcja kolorów, autyzm, klasa, edukacja