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Review Paper

The Impact of Physical Learning Environments on Creativity in Educational Settings: A Systematic Review

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Abstract
This study conducts a thorough literature review to explore the relationship between the physical learning environment and creativity. Addressing a gap in understanding how specific attributes impact creative processes, the research aims to inform the development of innovative learning environments. Using a four-step methodology, the study involves selecting relevant articles, creating a classification framework, analyzing environmental factors' effects on learning, and interpreting findings to elucidate the correlation between physical attributes and creativity. Bibliometric analysis reveals growing scholarly interest in creative spaces. Findings emphasize the substantial impact of elements like furniture flexibility, resource accessibility, and lighting conditions on creative thinking. Key themes highlight critical factors like lighting, furniture arrangement, and diverse roles of environmental elements, contributing to enhanced cognitive performance. The study underscores the potential of optimized learning spaces to nurture creativity, promote problem-solving skills, and stimulate innovation. By enriching knowledge on the influence of physical environments on creativity, this research provides valuable insights for educators, designers, and policymakers aiming to create inspiring and effective learning environments.

Keywords: *Physical environment, Creativity, Educational settings, Classroom design, Learning space*.

1. INTRODUCTION

The design of physical learning environments plays a crucial role in fostering creativity, an essential component of education. This literature review aims to guide future research on spatial affordances, creative activities, and design solutions within educational spaces, focusing on how these elements can nurture creativity. The insights gained will be valuable for educators, designers, and policymakers in creating innovative and effective learning environments.

While existing studies have extensively explored the significance of creativity in various contexts, there remains a need for a deeper understanding of how creativity manifests and thrives specifically within educational settings. Creativity in education involves more than just individual cognitive processes; it is significantly influenced by the physical environment where learning occurs. The concept of "creative press," introduced by Rhodes (1961), emphasizes the interaction between individuals and their surroundings as a critical factor in creative development [1].

Research indicates that the physical design of educational spaces can significantly impact creative thinking. Key aspects such as furniture flexibility, resource accessibility, and lighting conditions have been shown to enhance cognitive performance and stimulate innovation. Furthermore, an innovative and supportive physical learning environment is instrumental in fostering creativity among students [2]. However, this review also identifies a critical need for more in-depth analysis and the inclusion of specific examples from the reviewed literature. By doing so, the paper will strengthen its arguments and provide more practical relevance to the findings.

This literature review focuses on the Support for Creativity in a Learning Environment (SCALE)

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framework, which comprises three core components: Learner Engagement, Physical Environment, and Learning Climate [3]. By examining these components, we aim to identify how different physical attributes of learning environments contribute to creativity. Recent studies have also highlighted the influence of technological integration and sustainability on creative outcomes in educational settings [4-6].

Numerous studies have explored various architectural and environmental factors that influence creativity, including spatial layouts, types of spaces, ambient conditions, and sensory elements such as lighting and color [7, 8]. These studies suggest that well-designed environments not only support but also actively enhance creative thinking by providing spaces for exploration and experimentation. In addition to indoor environments, outdoor learning spaces have been shown to positively impact creativity by offering diverse stimuli and experiences [2]. The availability of resources, flexible furniture, and visually engaging settings is crucial in promoting a positive learning climate and increasing learner engagement [3].

Despite extensive research, gaps remain in understanding the specific physical attributes that most effectively foster creativity and the moderator variables that influence this relationship. For instance, there is limited research on how emerging technologies and sustainable design practices specifically impact creativity in educational settings. Additionally, more recent references and critical analyses of current methodologies are needed to strengthen the existing body of literature. There is also a need to explore the longitudinal effects of physical environments on creativity to determine whether short-term improvements lead to sustained creative development. This review seeks to address the following research queries:

1. What specific physical attributes of learning environments have studies examined regarding their impact on creativity?
2. Which moderator variables influence the relationship between the physical environment and creativity within educational settings?
3. Which variables have been studied to understand the relationship between environmental qualities and their impact on creativity?

In this paper, we aim to provide an overview of the current state of research on physical learning environments and their impact on creativity through a systematic literature review. This review will serve as a valuable resource for educators, designers, and researchers to better understand the influence of physical space on creative outcomes and to identify research gaps for future studies in this field.

2. METHOD

The methodology employed in this study is adapted from the approach developed by Cuentas, Penabaena-Niebles, and Garca [9] for conducting the literature review. The following steps were followed to establish the methodology:

– Step 1: Search and select articles related to the impact of the physical environment on creativity.

– Step 2: Create a classification framework with a number of categories that allows items to be sorted according to their content.

– Step 3: Utilize the classification framework to structure, condense, and analyse the effects of environmental factors on the process of learning.

– Step 4: Results analysis, discussion, conclusions, and definitions of possible future research.

The classification system employed in this study comprised seven categories, enabling a systematic analysis of the literature. Through this analysis, the researchers aimed to compare and establish relationships between various approaches, identify gaps in current knowledge, propose directions for future research, and underscore the significance of studying the impact of the physical environment on creativity within the academic domain.

Search strategy

To ensure a comprehensive search for relevant literature on learning spaces, specific criteria, databases, and keywords were employed. The following steps were taken to conduct an effective search:

– Search Criteria: The search criteria focused on identifying papers that specifically addressed the physical attributes of creative spaces within learning environments. This targeted approach ensured that the selected literature was directly relevant to the topic of interest.

– Databases: To obtain a wide range of literature, multiple reputable academic databases were utilized, including Google Scholar, Science Direct, and Scopus. By searching across different databases, a more diverse collection of sources was accessed.

– Keywords: Carefully chosen keywords were used to conduct the search as shown in figure 1. The selected keywords were aimed at capturing various aspects of the topic, including terms such as "creative space," "creative environment," "learning space," "classroom design," "physical attributes," "learning environment," and "creativity." This comprehensive

selection of keywords ensured that a broad spectrum of literature was considered.

Table .1 provides an organized overview of the key parameters used in the database searches, presenting the search terms and their corresponding values. This table facilitates a clear understanding of the search strategy employed and the specific terms used to retrieve relevant literature. By employing this systematic approach, the search process was comprehensive, targeted, and inclusive of diverse perspectives on the subject of creative spaces in learning environments.

Selection process

To ensure the relevance and quality of the selected papers, a thorough review process was conducted based on the following criteria:

– Criterion 1: Availability of full text: The full text of the journal and papers is available in the databases or accessible sources. Book or Book chapters are excluded.

– Criterion 2: Language: The paper should be in English to ensure ease of understanding and accessibility for the intended audience.

– Criterion 3: Relevance topic: The paper primarily focuses on physical attributes of learning environment. Papers related to work spaces or working environments are excluded.

By applying these rigorous criteria, the research team ensured that the selected papers were directly relevant to the research topic of physical attributes of learning environments and provided comprehensive insights into creative spaces in educational settings. Through the analysis of abstracts, keywords, and introductions of the retrieved studies, a thorough understanding of the research topic was achieved. It is noteworthy that a significant proportion of articles addressing the influence of physical spaces on creativity have primarily focused on work environments. However, we deliberately excluded these articles from our analysis, narrowing our focus to a specific subset of literature:

Figure 1 outlines the process of selecting studies for a systematic review. The process begins with the identification phase, where 151 records are identified through database searching and an additional 72 records through other sources, totaling 223 records. After removing duplicates, 187 unique records remain. During the screening phase, all 187 records are reviewed, resulting in the exclusion of 15 records, leaving 172 full-text articles assessed for eligibility. In the eligibility phase, 109 full-text articles are excluded for various reasons, resulting in 63 studies included in the qualitative synthesis. Figure 1 visually represents the results obtained through the search strategy and application of eligibility criteria.

Classification scheme

The physical environment has been defined and categorized in numerous research studies. It refers to the tangible, observable components and circumstances that surround people in a given area. These factors significantly influence people's experiences, actions, and well-being. A natural environment is characterized by a low level of "artificiality" [10], a built environment with natural elements has a medium level of artificiality [11], and a virtual environment has a high level of artificiality [12, 13]. The terms Architecture (referring to the building), Furniture (referring to interior design components like mobile furniture), and Resources (referring to additional equipment and work materials) were used by Weinberg and colleagues (2014) to describe the degree of fixity (immobility), which ranged from fixed to adjustable [14]. Hemlin et al. (2008) categorize the physical environment into facilities, buildings, architecture, location, climate, and equipment, without providing specific definitions for each category [15].

According to Jan Dul's hierarchical model, as shown in Figure 2, the physical environment is considered an independent variable that influences users' creativity, the dependent variable. This influence occurs through the mediation of moderator variables such as functionality, meaning, and mood [16]. Jan Dul's framework is particularly well-suited for our research as it emphasizes the dynamic interaction between individuals and their environment. It provides a comprehensive and systematic approach to understanding how specific elements, spaces, buildings, and locations in the physical environment can influence the creative process. Dul's categorization of the physical environment, as shown in Figure 2, underscores the interaction between people and their environment. Dul proposes four categories: "Element," "Space," "Building," and "Location" [16].

By adopting this framework, we aim to gain deeper insight into the complexities of the relationship between the physical environment and creativity. It allows us to examine how different aspects of the physical environment act as determinants of creative outcomes, helping us identify factors that can enhance or hinder creativity in educational, workplace, and other relevant settings. We will proceed to enhance and refine this framework by incorporating recent

research papers. The classification process relied on seven categories:

– What research methods were used to investigate the impact of the physical environment on creativity in educational settings?

– How did the study evaluate the influence of physical elements on creativity in the educational context?

– What is the analysis population for the study, i.e., the group of participants included in the data analysis?

– What are the physical attributes of learning environments that are considered in studies on creativity?

– Which moderator variables influence the relationship between the physical environment and creativity in educational settings?

– How was the influence of special organization on creativity addressed in the study?

– Which variables were examined to understand the relationship between environmental qualities (light, noise, temperature, air quality) and their impact on creativity?

The review of the articles involved categorizing them based on the parameterized responses to each question [17]. These responses were used to divide the articles into distinct categories. The categorization process was guided by an initial review, and the resulting categories are outlined in Appendix 1. This literature review approach facilitates the systematic compilation of the most relevant studies on the subject, methodically describing the research background. Ultimately, this technique enables the creation of meaningful dialogue and the extraction of valuable insights to guide future research directions in this area.

Table 1. search strategy and keywords

Search String	"Creative space," "learning space," "classroom design," "educational environment," "physical attributes," "creativity,"
Databases	Google Scholar, Science Direct, and Scopus
Document type	Journal articles, Conference proceedings
Searched in	Title, abstract, and keywords only
Language	English
Last update	15 November 2023

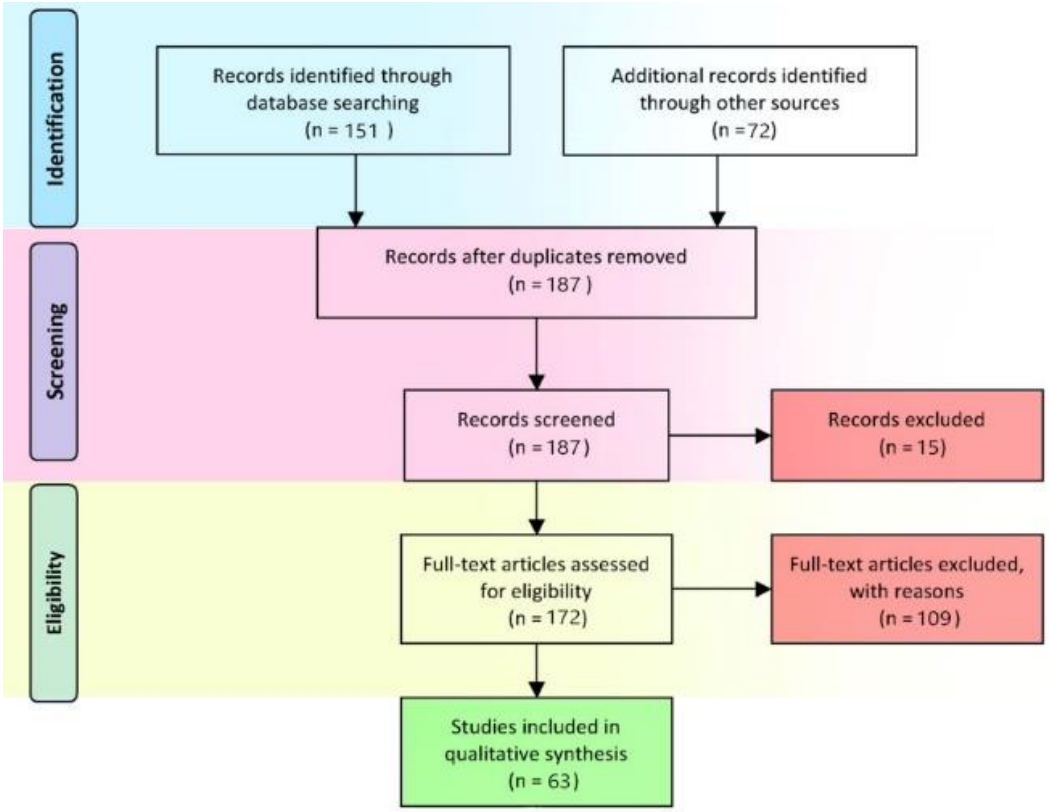

Fig 1. Search strategy and application of eligibility criteria

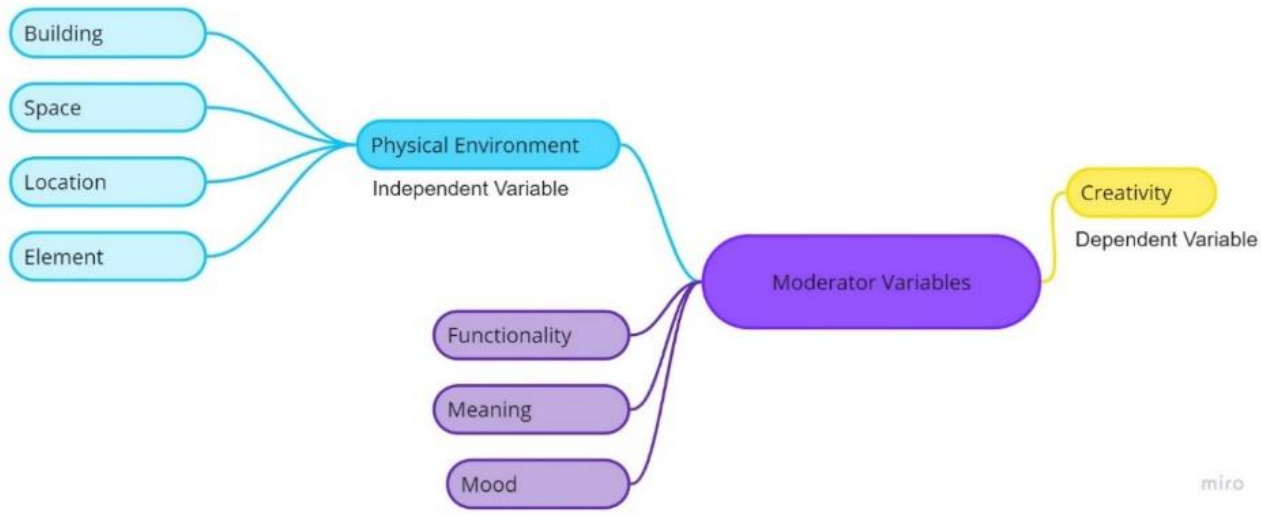

Fig 2. Jan Dul's theoretical framework

3. RESULTS

Bibliometric analysis

Various approaches have been suggested for analysing literature reviews, including bibliometric analysis as proposed by Pritchard [17]. This method aims to provide a comprehensive understanding of the research field, including its progression, limitations, and future prospects. As part of this review, a bibliometric analysis was conducted on the 63 studies identified earlier. This analysis encompassed examining authorship, keywords, affiliations, citations, co-citations, and geographical distribution. The following section presents the detailed findings of the bibliometric analysis.

Number of most relevant publications and journals

Figure 3 shows the publication trends in the field of creative spaces from 1991 to 2023, revealing notable patterns and shifts. Initially, there was limited scholarly attention, but over time, there was a gradual increase in interest and contributions, highlighting the growing recognition of the significance of creative spaces. In the early 2000s, there was a surge in research activity as scholars recognized the potential of these spaces for fostering creativity in various domains. From 1990 to 2023, there was a remarkable spike in publications, indicating a turning point with increased interdisciplinary approaches and advancements in technology contributing to the exploration of creative spaces. It is expected that publication trends in creative spaces will continue to rise, driven by a growing awareness of the importance of fostering creativity and innovation.

Table 2 displays the journals that were consulted to gather articles resulting from the aforementioned eligibility process. A total of 63 articles pertaining to the research topic were compiled from 41 eligible journals spanning the past 33 years. The articles, as indicated in Table 2, were published in journals that demonstrate a notable interest in creative spaces.

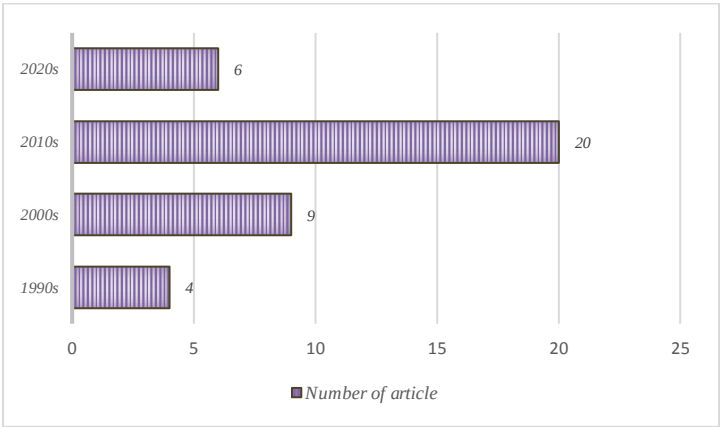

Fig 3. Number of annual publications by year

Keyword Analysis and Clustering

By utilizing VOS viewer [18], keywords that met a predefined threshold value and were present in the database were used to generate a visual representation. Table 3 displays the keywords chosen based on their frequency of occurrence and overall link strength. Additionally, the resulting keyword network analysis led to the classification of clusters, which are also presented. The terms with the highest frequency (more than three occurrences) in the analysed articles are shown in Figure. 4. In this visualization, the node size represents the frequency of use, the connections between nodes depict the co-occurrence of two terms, and the colours represent clusters of keywords that are frequently used together.

Table 2. Journals used in the collection of articles in the literature search.

ID	Journals	No.	ID		No.
1	Thinking skills and creativity	8	22	Design Studies	1
2	Journal of environmental psychology	5	23	Technology and Engineering Teacher	1
3	Creativity Research Journal	2	24	Creative Education	1
4	Art, Design & Communication in Higher Education	2	25	Creativity and HCI: From experience to design in education	1
5	New Zealand Journal of Educational Studies	2	26	European Planning Studies	1
6	Science Educator	2	27	Frontiers in human neuroscience	1
7	Journal of experimental psychology: learning, memory, and cognition	2	28	Indonesian Journal of Educational Research and Technology	1
8	College & Research Libraries	1	29	Instructional Science	1
9	Australian Journal of Teacher Education	1	30	Research Papers in Education	1
10	Ergonomics	1	31	Higher Education	1
11	Innovations in education and teaching international	1	32	Journal of Building Engineering	1
12	Chemical senses	1	33	Journal of Creativity	1
13	Creativity and innovation management	1	34	Journal of Consumer Research	1
14	Computers & Education		35	Cerebral Cortex	1
15	Journal of knowledge management	1	36	Science	1
16	New Review of Academic Librarianship	1	37	Scandinavian journal of psychology	1
17	Computers in Human Behaviour	1	38	Perceptual and motor skills	1
18	Urban Forestry & Urban Greening	1	39	Perceptual and motor skills	1
19	Journal of Higher Education Theory & Practice	1	40	International Journal of Art & Design Education	1
20	Sustainability	1	41	Architectural Engineering and Design Management	1
21	Design Studies	1	42	Conference proceeding	9
	Total			63	

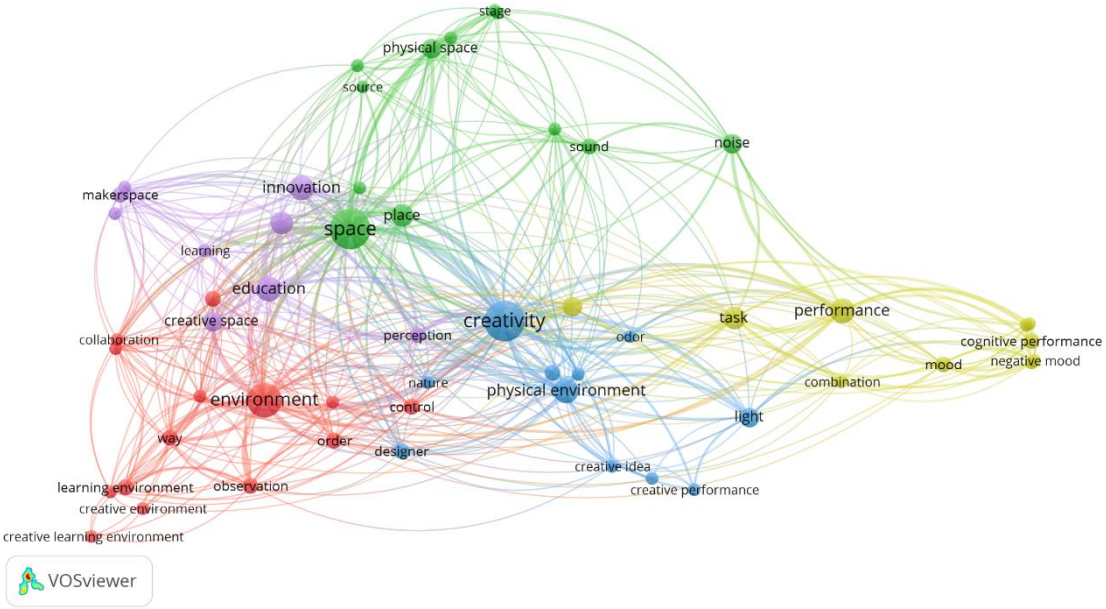

Fig 4. Keyword co-occurrence network

These clusters will be discussed in detail in Section 4. The VOS viewer-generated network visualization illustrates the relationships and frequency of keywords related to creativity in educational environments. The clustering of keywords reveals five distinct themes, each associated with specific aspects of the physical learning environment that influence creativity.

1. Role of Furniture and Spatial Layout (Red Cluster): This cluster focuses on the physical aspects of the learning environment, such as furniture arrangement and spatial layout.
2. Utilization of Natural and Outdoor Environments (Blue Cluster): This theme emphasizes the importance of integrating natural and outdoor elements into learning environments.
3. Influence of Ambient Conditions (Green Cluster): This cluster highlights the impact of ambient conditions on creativity and cognitive performance.
4. Flexibility and Adaptability in Learning Spaces (Yellow Cluster): This theme underscores the importance of adaptable and flexible learning environments.
5. Integration of Technology and Innovative Tools (Purple Cluster): This cluster focuses on the role of technology and innovative tools in enhancing creativity in educational settings.

Results of the classification scheme

In this study, 63 articles were meticulously categorized using the scheme outlined in Section 2.3. The outcomes for each research question are meticulously presented in Appendix 2. The coding of categories in Appendix 2. precisely aligns with the categories specified in Section 2.2, Classification Scheme, where each capital letter (A, B, C, D, E, F, and G) denotes a category, and Roman numerals signify subcategories. The table specifies the corresponding subcategory for each category based on meticulous analysis of each article.

Physical Environment and Interaction

50% investigations, as shown in Figure. 5, focused on the "Element" category in their studies. Their primary focus was on furniture in terms of flexibility and adaptability of the indoor environment [2, 19-22], tools [3, 21-26], technology [24-27], and the availability of materials and resources [2, 3, 21, 22, 27-30]. Following closely is the "Space" category, which accounts for 28.6% of the diagram. The "Building" category represents 11.4% of the diagram, indicating significant attention to the architectural structure, construction, and design of the physical environment. Lastly, the "Location" category constitutes 10% of the diagram, indicating a smaller but still relevant portion of research or analysis related to the geographical or contextual positioning of the environment.

Table 3. Identified clusters and themes.

Theme No.	Cluster	Keywords	Theme Label
1	Red	environment, education, observation, learning environment, creative environment, collaboration	Role of Furniture and Spatial Layout
2	Blue	space, physical environment, place, nature, control, perception, designer	Utilization of Natural and Outdoor Environments
3	Green	sound, noise, task, performance, cognitive performance, negative mood, odor	Influence of Ambient Conditions
4	Yellow	flexibility, adaptability, light, mood, combination	Flexibility and Adaptability in Learning Spaces
5	Purple	innovation, makerspace, learning, creative space	Integration of Technology and Innovative Tools

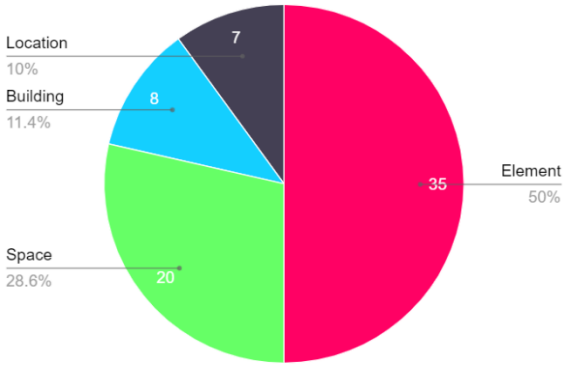

Fig 5. Physical environment

Several studies have examined the relationship between spaces, outdoor environments, and furniture layout in educational settings and their impact on creativity. As shown in Figure. 6., Out of the 63 papers reviewed, 21 studies specifically focused on the role of spaces in facilitating creativity, emphasizing the importance of creating conducive environments and utilizing systems for knowledge creation and interdisciplinary collaboration [21, 31, 32]. These studies highlighted the positive influence of spatial layouts, architectural details, and furniture design on enhancing creativity within the design process. For example, Davies et al. (2013) found that adaptable spaces support creative skills development by allowing learners to control and personalize their learning environments [2]. Another study by Saorín et al. (2017) highlighted the role of maker spaces in engineering education, showing that flexible environments and tools like 3D printers enhance creative expression and innovation [26]. Additionally, McCoy & Evans (2002) explored the impact of natural environments on creativity, finding that exposure to natural materials and settings promotes creative thinking [28]. These examples illustrate the diverse ways in which physical environments can be designed to enhance creativity in educational settings.

Additionally, 8 papers explored the impact of the outdoor environment on creativity, recognizing the significance of natural surroundings in fostering creative experiences and outcomes [10, 21]. The arrangement and layout of furniture within learning spaces were examined in five papers, acknowledging their influence on student engagement, perceptions of the learning space, and creative achievements [22, 33]. Flexible furniture arrangements, diverse seating options, and ergonomic designs were found to support creativity, collaboration, and innovation.

Impact of the Physical Environment on Creativity

Understanding the relationship between the environment and mood regulation was a primary focus of these investigations. For example, the study by Lan (2020) demonstrated that specific lighting conditions, such as warm lighting, significantly enhanced students' mood and creative performance [34]. Furthermore, seven studies were dedicated to exploring the "Meaning" variable, which encompassed the symbolic and interpretative aspects of the physical environment. These studies, such as the one by Groves & Marlow (2016), aimed to understand how individuals' perceptions of meaning and their experiences are influenced by the design, aesthetics, and cultural importance of the environment [8]. By analyzing these moderator variables, researchers aimed to gain a comprehensive understanding of how functionality, mood, and meaning interact to shape individuals' experiences and well-being within the physical environment.

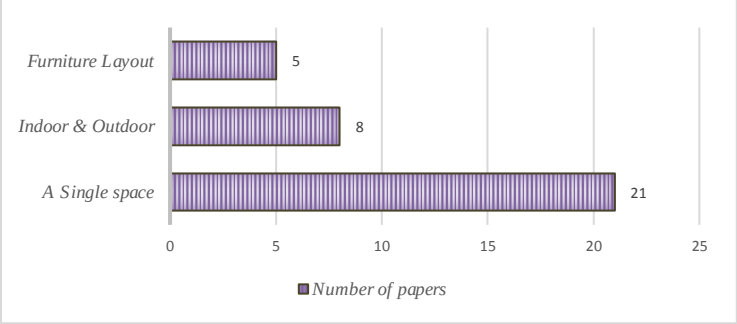

Fig 6. Special configuration

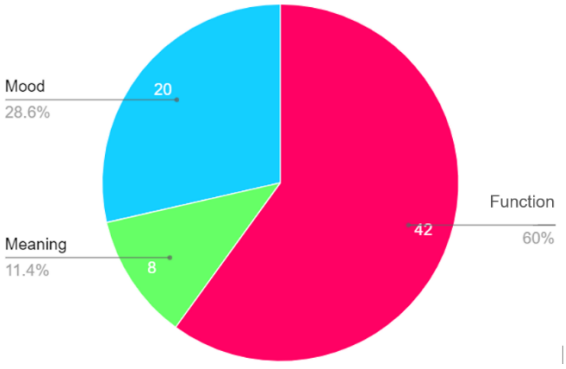

Fig 7. Moderator variables

The chart, as shown in Figure. 7, provides a comprehensive overview of the distribution of studies based on different moderator variables. Out of the 63 research papers reviewed, the majority, comprising 42 studies, focused on the "Functioning" variable. These studies, like the one by Thoring et al. (2018), aimed to investigate the effectiveness, usefulness, and usability of the physical environment [22]. Key areas of focus included examining the impact of design decisions, furniture placements, and spatial layout on enhancing functionality. Additionally, 20 studies specifically explored the "Mood" variable, delving into how various elements of the physical environment, such as lighting, color schemes, and sensory inputs, influence individuals' emotional states and overall moods.

As shown in Figure. 8 out of the studies reviewed, 6 studies specifically focused on examining "Lighting conditions, colour schemes, and visual stimuli" in the classroom. These studies investigated the impact of lighting conditions and colour schemes on individuals' mood, cognitive performance, and subjective preferences [35, 36]. Furthermore, 26 studies explored the influence of "Furniture arrangement, spatial layout, and accessibility to creative materials". These studies emphasized the importance of configuring the learning space to facilitate creativity and engagement among students [21, 22, 24, 32, 33]. In addition, 7 studies delved into the significance of "Ambient noise levels and acoustic quality" in the learning environment. These studies highlighted how background sound can affect students' reading comprehension, recall, and mental arithmetic [22, 37, 38].

Creative Educational Spaces

Jan Dul's hierarchical categorization of the physical environment emphasizes the interaction between individuals and their surroundings, focusing on proximity. The framework includes four main categories: "Element," which encompasses sensory aspects of the immediate physical environment; "Space," referring to physical areas for activities such as public spaces and outdoor settings; "Building," describing organized and interconnected places like office buildings; and "Location," which denotes the geographical position of the environment such as neighbourhoods or regions. These categories serve to illustrate environmental traits, keywords describing these traits, and demonstrate how research connects these traits to creativity, as detailed in Table 5. Below, we delve deeper into the specifics of this research.

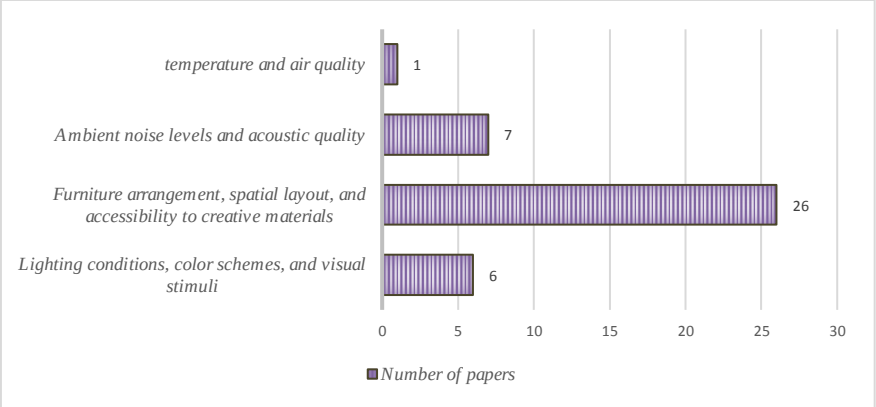

Fig 8. Environmental qualities

Table 4. Examples of empirical research that highlight aspects of the physical environment that are associated to creativity

Class	Subclass	Characteristic	Keywords	Source
Element	Ambient condition	Light	Lightening condition, darkness, colour temperature of light, daylight/artificial light	[21, 27, 28, 34, 35, 39, 40]
		Sound	Music, noise, background sound	[21, 37, 38, 40-42]
		Smell	Odour condition	[43]
		Colour	Colour temperature of objects/walls	[21, 27, 28, 36, 44, 45]
		Indoor climate	Air temperature, air quality, draught	[21, 40, 44]
	Artefact	Materials	Natural materials (e.g., wood), manufactured materials (e.g., metal)	[21, 28]
		Plants	Indoor plants	[10, 21, 28, 46, 47]

Class	Subclass	Characteristic	Keywords	Source
		Furniture	Chairs, tables, seats, Comfort, furniture layout and features	[2, 3, 21, 22, 24, 27, 29, 30, 32, 48-50]
		Information sources and technology	Computer, books, 3D printers, Educational tools, resources, example of previous students work material, specialized equipment, social media, augmented reality, virtual environment, digital prototyping	[2, 22, 24, 26, 32, 51-59]
		Decoration	Art, aesthetic, design	[27]
Space	General space	Individual	Individual room, focus space, personalization	[22, 29, 32]
		Shared	Collaboration Space, exhibition space, presentation space, sharing space, engaging space, activate participation, creative environment	[21, 22, 24, 32, 33, 51, 60-62]
		Flexibility and adaptability	Possibility to change rooms, making space, experimentation space, flexible space, adaptability, modularity	[2, 20, 22, 24, 25, 29, 32, 33, 49, 50, 60, 63]
		Inspiration and interaction	Ideation space, space for divergent thinking, brainstorming, collaboration, convergent thinking, intermission space, exploration space, networking and questioning space, play, design jams	[20, 22, 23, 32, 48, 49, 51, 52, 61, 62, 64-66]
		Privacy	Space for isolation, reflection, storage,	[20, 21, 67, 68]
		Relaxation	space for relaxation	[68, 69]
		Nature	Space in nature, built space predominantly with nature elements (plants, water, wood)	[10]
		Sense of ownership	Wellbeing Space, sense of belonging	[2]
		Culture	Culture of experimentation, risk-taking, and openness to new ideas, rules	[22, 32]
Building		Creativity Based	Enhancement of creativity, collaboration an innovation, exploration space	[19, 23, 25, 31, 33, 52, 60, 62]
		Activity based	Flexible building, incubation space, maker space, knowledge processing, workshops, studio	[2, 3, 22, 23, 29, 31-33, 52, 57, 63, 66]
Location		Innovation park	Dedicated group of buildings and infrastructure for creativity and innovation, play ground	[20, 70]
		Campus	Dedicated group of buildings and infrastructure for learning of students	[20, 71, 72]
		Urban development	Creative spaces, walking space, Space for exercise	[33, 63, 73, 74]
		Access to nature		[10, 21, 75]

Research Methods

Figure. 9 illustrates the research methods employed in 63 papers investigating the impact of the physical environment on creativity in educational settings. Five methods were identified: Experimental, Qualitative, Case study, Literature review, and Mixed method. The qualitative approach was the most prevalent, used in 24 studies, followed by experimental methods in 12 studies, and mixed methods in 11 papers. This diversity in approaches contributes to a comprehensive understanding of the complex relationship between the physical environment and creativity, aiding in the design of effective learning environments.

The experimental method, as demonstrated in the study by Toplyn and Maguire (1991), investigates the impact of the physical environment on creativity through controlled environment manipulation, establishing causal relationships and precise measurement [38]. Surveys, as utilized by Bieraugel and Neill (2017), have been employed as a research method to collect data on individuals' perceptions and experiences of the physical environment and its impact on creativity through structured questionnaires or interviews [20]. Case study analysis, as observed in the works of Setola and Leurs (2014) and Thoring et al. (2018), examines the impact of educational settings on creativity, analysing factors and context through observations, interviews, and document analysis [22, 33]. Literature reviews, exemplified by the study conducted by Lee and Lee (2023), examine research on the physical environment impacting creativity in educational settings, identifying key findings, trends, and gaps for further research [21].

The mixed method approach, as highlighted in the research by Setola and Leurs (2014), integrates various research methods to understand the impact of the physical environment on creativity in educational settings, enhancing validity and incorporating diverse perspectives [33]. By combining surveys, interviews, observations, and document analysis, researchers gain a more holistic understanding of the complex relationship between the physical environment and creativity.

As shown in Figure. 10 among the studies, surveys and questionnaires were used in 17 studies [2, 20, 22, 25, 32, 38, 48, 60, 71], while 10 studies involved observing and documenting students' interactions [3, 10, 28-30, 32, 63]. Cognitive tests or assessments were used in 14 studies [19, 22, 25, 27, 31, 38-40, 43, 71]. 20 studies gathered qualitative data from interviews or focus groups [10, 22, 30, 32, 33, 67]. Additionally, three studies focused on theoretical exploration [21, 25, 33].

As shown in Figure. 11 the participants in the reviewed articles spanned a range of different studies, reflecting diverse populations. Several studies focused on university students, such as [19, 20, 24, 26, 32, 38, 48, 63, 71]. School students were the main participants in studies conducted by [3, 30, 33, 36, 37, 67] focused their study on teachers, examining their role in fostering creativity. Some studies did not specify their participants, including [21-23, 25, 27, 29, 31, 39, 40, 43, 60]. Others, such as [10, 28, 35, 68], involved participants from different backgrounds or did not specify a specific group. The diversity of participants across these studies contributes to a broader understanding of the relationship between creativity and various participant characteristics.

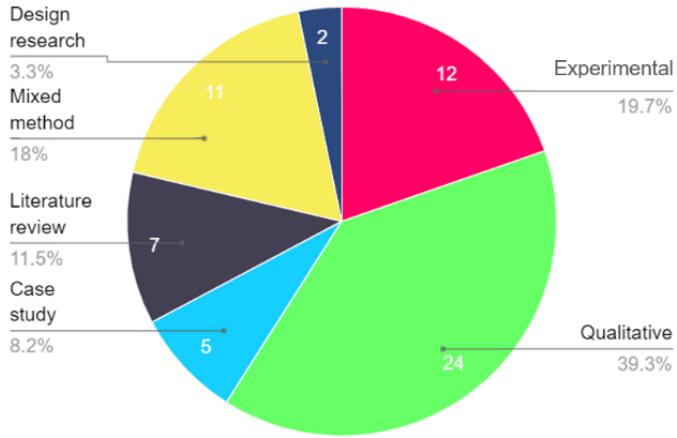

Fig 9. Research method

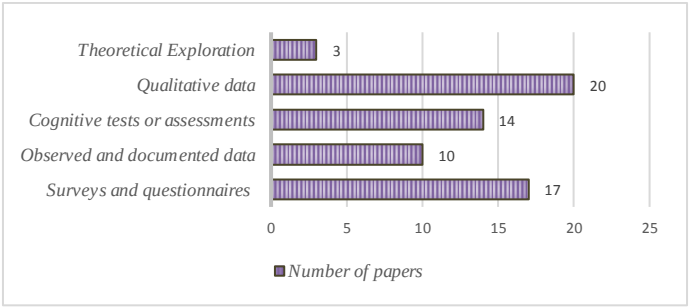

Fig 10. Evaluation of data

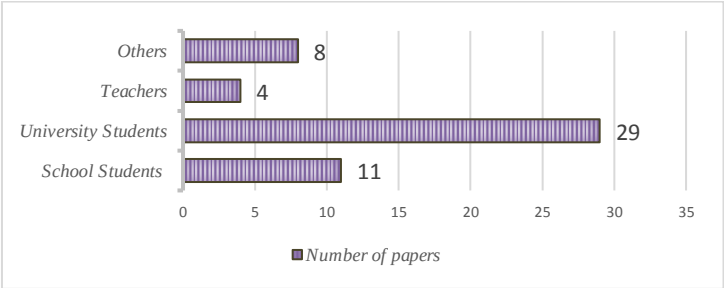

Fig 11. Research population

Leurs et al. (2013) examined university students' creativity, focusing on project details, space organization, and group discussions and decision-making. The study aimed to understand the relationship between the physical environment and creativity.[63]. McCoy and Evans (2002) studied the relationship between environmental conditions, such as lighting and noise, and creativity potential in undergraduate psychology students [76]. Starkey et al. (2021) studied furniture use in a New Zealand primary school learning environment, examining its impact on students' learning and creativity [30]. Alhussain et al.'s study analysed 45 Cardiff Metropolitan University students, focusing on their creative thinking abilities and perceptions of different environments [19].

4. DISCUSSION

Flexibility and Adaptability in Learning Spaces

Flexibility and adaptability in learning spaces have emerged as significant factors in fostering creativity. Studies focusing on furniture and tools underscore the importance of these elements in creating dynamic and adaptable educational environments. Alhussain et al. (2016), Bieraugel & Neill (2017), and Thoring et al. (2018) emphasize the role of flexible furniture arrangements that allow for reconfiguration based on the needs of various activities [19, 20, 22]. This adaptability enables students to control and personalize their learning environments, which supports creative skills development [2]. The inclusion of tools such as 3D printers and modular furniture in maker spaces further supports creative expression and innovation, as demonstrated by Saorín et al. (2017) and Richardson & Mishra (2018) [3, 26]. These findings underscore the necessity for educational spaces to be designed with flexibility and adaptability in mind to facilitate creative thinking and problem-solving.

However, while the benefits of flexible learning spaces are well-documented, significant challenges and limitations exist. These include high costs associated with redesigning and maintaining flexible environments, the need for extensive teacher training, and potential resistance from institutions accustomed to traditional classroom setups. Additionally, logistical issues such as the physical constraints of existing school infrastructure and unequal access to flexible learning technologies across different schools pose significant challenges. The effectiveness of these environments can also depend on the specific educational context and the readiness of both educators and students to adapt to new methods of learning and teaching.

Educators and designers should prioritize creating flexible learning spaces that can be easily reconfigured to support diverse teaching methods and activities. Investing in modular furniture and adaptable layouts can significantly enhance students' creative potential.

Influence of Ambient Conditions

Ambient conditions, including lighting, sound, and air quality, significantly impact students' mood and creative performance. Lan (2020) and McCoy & Evans (2002) show that specific lighting conditions, such as warm lighting, can enhance mood and creativity [28, 34]. Studies on sound and noise levels reveal that moderate background noise can stimulate creative thinking, while excessive noise can hinder it [37, 38]. The impact of air quality on cognitive performance also highlights the importance of maintaining a comfortable indoor climate to optimize creative outcomes [40]. These findings indicate that carefully managing ambient conditions is crucial for creating environments conducive to creativity. Schools should implement lighting systems that allow for adjustable lighting conditions and ensure proper acoustic treatments to balance noise levels. Additionally, maintaining good air quality through effective ventilation systems is essential to support a conducive learning environment.

While optimizing ambient conditions can significantly enhance cognitive performance and creativity, there are several challenges and limitations. Implementing these changes can be costly and logistically complex, particularly in older buildings with outdated infrastructure. Additionally, the effectiveness of these modifications can vary based on individual preferences and specific learning needs. For example, some students may find certain ambient conditions, such as background music, distracting rather than beneficial. Furthermore, maintaining optimal ambient conditions requires ongoing monitoring and adjustment, which can be resource-intensive.

Role of Furniture and Spatial Layout

The arrangement and layout of furniture play a pivotal role in influencing student engagement and creativity. Research by Setola & Leurs (2014) and Thoring et al. (2018) demonstrates that flexible furniture arrangements, diverse seating options, and ergonomic designs support creativity and collaboration [33, 77]. The studies indicate that properly designed furniture and spatial arrangements

not only ensure comfort but also improve the functionality of learning environments, enabling students to engage more effectively in creative tasks. The capacity to adapt spaces for various activities and group sizes is crucial for cultivating an atmosphere that promotes creative thinking and innovation.

Within this context, researchers have commonly examined the effects of furniture arrangement, spatial layout, and access to creative materials on creativity. Notably, studies have primarily focused on analysing the organization and design of individual spaces, rather than exploring the interconnections between different spaces and furniture layouts in a broader context. This narrow focus may overlook how the flow and interaction between multiple learning areas influence overall creativity and collaboration. Designers should aim to create versatile furniture layouts that support both individual and group activities. Incorporating diverse seating options and ergonomic designs can enhance student comfort and engagement.

Utilization of Natural and Outdoor Environments

Incorporating natural and outdoor environments into educational settings has been demonstrated to enhance creativity. Research by McCoy & Evans (2002) and Plambech & Van Den Bosch (2015) underscores the beneficial impact of natural surroundings on creative thinking [10, 28]. Exposure to natural elements like plants and natural light has been shown to reduce stress and enhance cognitive performance, creating an environment conducive to creativity. Outdoor learning spaces offer varied stimuli and experiences that can inspire creative ideas and problem-solving. These findings underscore the significance of integrating natural elements and outdoor environments into educational designs to foster creative learning.

Incorporating natural elements like plants and natural materials into indoor spaces also promotes a conducive environment for creativity. These environments provide sensory stimulation and opportunities for exploration, which support cognitive and creative development. For example, classrooms adorned with indoor plants and natural materials have been found to enhance students' attention and engagement, ultimately leading to improved creative outcomes (Davies et al., 2013) [2]. Schools should integrate natural elements such as indoor plants and maximize natural lighting in classrooms. Developing outdoor learning spaces can provide additional opportunities for creative engagement.

Educators and designers should prioritize integrating natural elements and outdoor learning spaces into educational environments to cultivate creativity. These spaces offer distinct opportunities for sensory engagement and serve as versatile settings for diverse educational activities. By blending indoor and outdoor elements in learning environments, educators can provide students with varied experiences that stimulate their senses and promote innovative thinking.

Integration of Technology and Innovative Tools

The integration of technology and innovative tools in educational spaces is crucial for enhancing creativity. Studies by Passehl-Stoddart & Snipes (2020) and Santos et al. (2021) show that technologies such as augmented reality, virtual environments, and digital prototyping tools can significantly boost creative expression and innovation [24, 25]. The presence of technological resources allows students to explore new ideas and tackle complex problem-solving tasks. Incorporating these tools in educational settings enhances the learning experience and prepares students for future challenges in a technology-driven world. These findings underscore the importance of ongoing investment in technological infrastructure to support creative education. Schools should prioritize investing in state-of-the-art technological tools and resources, such as digital fabrication tools, virtual reality setups, and other innovative technologies, to empower students to explore and enhance their creative skills.

The rapid advancement of technology presents challenges for educational institutions striving to stay current with the latest tools and resources. Moreover, there is a concern about excessive dependence on technology, potentially diverting attention from crucial aspects of creative development like hands-on activities and in-person collaboration. Future research should focus on examining the equilibrium between technology and traditional creative pursuits, as well as devising sustainable strategies for investing in educational technology.

6. CONCLUSION

This literature review highlights the crucial role of physical learning environments in nurturing creativity within educational settings. Key factors identified include flexibility and adaptability, ambient conditions, furniture and spatial layout, natural and outdoor environments, and the integration of technology and innovative tools. Flexible learning spaces equipped with modular furniture and advanced tools like 3D printers notably enhance students'

creative abilities. Optimal ambient conditions, such as adjustable lighting and controlled noise levels, support creative thinking by influencing mood and cognitive performance. Integrating natural elements and developing outdoor learning spaces offer diverse stimuli that foster creative thinking, while advanced technologies enable engagement in complex problem-solving and innovative tasks.

Despite the advantages outlined, significant challenges such as high costs, logistical complexities, and the necessity for extensive teacher training remain prevalent. Many studies rely on controlled laboratory settings, which might not fully encompass real-world complexities. Addressing these practical challenges and ensuring equitable access to flexible learning technologies are crucial steps forward.

To enhance educational practices, we propose several recommendations: creating adaptable learning spaces with modular furniture, installing adjustable lighting systems and effective acoustic treatments, and integrating indoor plants and natural lighting. Additionally, investing in state-of-the-art technological tools and cultivating outdoor learning spaces can offer additional opportunities for fostering creative engagement.

Future research should prioritize longitudinal studies to comprehensively grasp the enduring effects of physical environments on creativity. It should also delve into the interactions among various environmental factors, explore the synergy between digital tools and physical spaces, and experimentally assess how natural elements affect creativity. Broadening the scope to encompass diverse educational contexts and cultural settings will ensure that findings are globally relevant and applicable.

In conclusion, by implementing these recommendations and focusing on the outlined research directions, educators and designers can create educational environments that substantially enhance students' creative potential. This approach supports the development of innovative and effective learning spaces tailored to foster creativity and maximize educational outcomes.

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APPENDIX 1

1. What research methods were used to investigate the impact of the physical environment on creativity in educational settings?
    i. Experimental Method
    ii. Qualitative approach
    iii. Case Study Method
    iv. Literature Review Method
    v. Mixed method
    vi. Design-Based Research

2. How did the study evaluate the influence of physical elements on creativity in the educational context?
    i. Surveys and questionnaires
    ii. The researchers observed and documented students' interactions
    iii. Cognitive tests or assessments
    iv. Qualitative data from interviews or focus groups
    v. Theoretical Exploration

3. What is the analysis population for the study, i.e., the group of participants included in the data analysis?
    i. School students
    ii. University students
    iii. Teachers
    iv. Others

4. What are the physical attributes of learning environments that are considered in studies on creativity?
    i. Element
    ii. Space
    iii. Building
    iv. Location

5. Which moderator variables influence the relationship between the physical environment and creativity in educational settings?
    i. Functionality
    ii. Meaning
    iii. Mood

6. How was the influence of special organization on creativity addressed in the study?
    i. Examining the relationship between spaces
    ii. Investigating the relationship between spaces and outer spaces
    iii. Analysing the impact of furniture layout

7. Which variables were examined to understand the relationship between environmental qualities (light, noise, temperature, air quality) and their impact on creativity?
    i. Lighting conditions, colour schemes, and visual stimuli in the classroom.
    ii. Furniture arrangement, spatial layout, and accessibility to creative materials.
    iii. Ambient noise levels and acoustic quality of the learning environment.
    iv. Factors such as temperature and air quality that can influence cognitive processes.

APPENDIX 2

Appendix 2. Indexing of reviewed articles.

ID	Authors	Year	A	B	C	D	E	F	G
1	Davies, Dan; Jindal-Snape, Divya; Collier, Chris; Digby, Rebecca; Hay, Penny; Howe, Alan	2013	iv	-	-	ii	i; ii	i; iii	ii
2	Saorín, José Luís; Melian-Díaz, Dámari; Bonnet, Alejandro; Carrera, Carlos Carbonell; Meier, Cecile; De La Torre-Cantero, Jorge	2017	i	i; iii	ii	i	i	i	ii
3	Hygge, Staffan; Knez, Igor	2001	i	iii	iv	iii	i; iii	i	iii
4	Knez, Igor	2001	i	iii	i	iii	i; iii	i	i
5	Richardson, Carmen; Mishra, Punya	2018	v	ii	iii	i	i	i	ii
6	Jankowska, Maja; Atlay, Mark	2008	ii	i	iv	ii	i; iii	i	ii
7	Alhussain, Danah; Loudon, Gareth; Wilgeroth, Paul	2016	i	iii	ii	ii	i; iii	i	-
8	Santos, Anne F; Barber III, Dennis; Harris, Michael; Haymore, John	2021	ii	iii	iv	i; ii	i	i	-
9	Warner, Scott A; Myers, Kerri L	2009	iv		-	i; ii	I	i	i
10	Starkey, Louise; Leggett, Victoria; Anslow, Craig; Ackley, Aniebietabasi	2021	ii	ii	i	I	i; iii	i	ii
11	Daniel, Graham R	2020	iii	-	i	ii	ii	-	-
12	Setola, Bruno; Leurs, Bas	2014	iii	v	i	i; ii	i	i	ii
13	McCoy, Janetta Mitchell; Evans, Gary W	2002	i	i; ii; iii	ii	i; ii	i; ii	i; iii	ii
14	Kristensen, Tore	2004	iv	v	iv	i	i	i; iii	ii
15	Oksanen, Kaisa; Ståhle, Pirjo	2013	ii	i; ii	-	i; iii	i	i	ii
16	Leurs, Bas; Schelling, Jasper; Mulder, Ingrid	2013	v	i; ii	ii	iii	i; ii	i	ii
17	Peschl, Markus F; Fundneider, Thomas	2014	iii	iv	-	ii	i	ii	-
18	Edström, Ann-Mari	2014	v	iv	iv	ii; iii	iii	-	-
19	Knez, Igor	1995	i	iii	iv	i	iii	-	i
20	Bieraugel, Mark; Neill, Stern	2017	ii	i	ii	ii	i	i	ii
21	Furnham, Adrian; Strbac, Lisa	2002	i	i; iii	i	i	iii	-	iii
22	Knasko, Susan C	1992	v	iv	iv	i	iii	-	iii
23	Steidle, Anna; Werth, Lioba	2013	i	iii	ii	i	iii	-	I
24	Thoring, Katja; Mueller, Roland M; Desmet, Pieter; Badke-Schaub, Petra	2018	v	v	-	i	i	i; iii	i; ii
25	Thoring, Katja; Luippold, Carmen; Mueller, Roland M	2012	v	iv	ii	ii	i; ii	i	Ii
26	Rittiner, Florian; Heck, Johannes; Meboldt, Mirko; Steinert, Martin	2016	iii	ii	ii	i; ii	i	-	-
27	Passehl-Stoddart, Erin; Snipes, Genifer	2020	v	i; ii	Ii	i; ii	i; ii	iii	ii
28	Lee, Jae Hwa; Lee, Soyeon	2023	iv	-	-	i; ii; iii; iv	i; ii; iii	ii	i; ii
29	Toplyn, Glenn; Maguire, William	1991	i	iii	ii	i	iii	-	iii
30	Soares, Isabelle; Yamu, Claudia; Weitkamp, Gerd	2020	iii	i; iv	ii	iii; iv	i	ii	-
31	Plambech, Trine; Van Den Bosch, Cecil C Konijnendijk	2015	ii	iv	iv	iv	iii	ii	-
32	Hong, Huang-Yao; Chang, Yu-Hui; Chai, Chin Sing	2014	ii	i	ii	ii	i	-	ii
33	El Bedewy, Shereen; Lavicza, Zsolt	2023	vi	-	i; iii; iv	-	i	-	ii
34	Sadrizadeh, Sasan; Yao, Runming; Yuan, Feng; Awbi, Hazim; Bahnfleth, William; Bi, Yang; Cao, Guangyu; Croitoru, Cristiana; de Dear, Richard; Haghighat, Fariborz	2022	iv	-	i; iv	i; iv	i; iii	-	iv

ID	Authors	Year	A	B	C	D	E	F	G
35	Swanzy-Impraim, Enock; Morris, Julia E; Lummis, Geoffrey W; Jones, Andrew	2023	vi	i; ii	iii	ii	i	-	ii
36	James, Molly A	2015	iv	iv	-	-	-	-	-
37	Tang, Tang; Vezzani, Valentina; Eriksson, Vikki	2020	ii	i; ii	ii; iii	i; ii	i	i	ii
38	Cremin, Teresa; Chappell, Kerry	2021	iv	-	i	-	i	-	-
39	Lasky, Dorothea; Yoon, Susan A	2011	ii	i	i	-	-	-	-
40	Park, Elisa L; Choi, Bo Keum	2014	ii	iv	ii	i	i	i	ii
41	Jamaluddin, Asham Bin; Zubaidah, Siti; Mahanal, Susriyati; Bahri, Arsad	2023	vi	iv	ii	i	i	-	ii
42	Çetin, Ekmel	2021	v	-	i	i	i	-	-
43	Bednář, Pavel; Danko, Lukáš; Smékalová, Lenka	2023	v	i; iv	iv	ii	i	i	-
44	Rasheed, Muhammad Imran; Malik, Muhammad Jawad; Pitafi, Abdul Hameed; Iqbal, Jawad; Anser, Muhammad Khalid; Abbas, Mazhar	2020	ii	iv	ii	i	ii	-	ii
45	Wei, Xiaodong; Weng, Dongdong; Liu, Yue; Wang, Yongtian	2015	ii	iv	ii	i	i	-	ii
46	Ismail, Fathin Amirah; Bungsu, Jabaidah; Shahrill, Masitah	2023	v	i	ii	-	i	-	-
47	Sagan, Olivia	2008	-	iv	ii; iii; iv	ii	i; iii	ii	-
48	Mäkelä, Maarit; Aktaş, Bilge Merve	2023	ii	iv	ii	iv	iii	ii	-
49	Mones, Precious; Massonnié, Jessica	2022	v	iii	ii	i	i;	-	iii
50	Almrott, Ceri	2022	ii	i	ii	i; ii	-	-	-
51	Lundström, Anette; Savolainen, Jussi; Kostiainen, Emma	2016	ii	i	ii	iii	iii	ii	-
52	Toplyn, Glenn; Maguire, William	1991	ii	iv	ii	i	i; iii	-	iii
53	Mehta, Ravi; Zhu, Rui	2009	ii	ii	iv	i	i	-	i
54	Shibata, Seiji;Suzuki, Naoto	2004	ii	iv	ii	i	iii	-	ii
55	Shibata, Seiji; Suzuki, Naoto	2002	ii	iv	ii	i	iii	-	ii
56	Takeuchi, Hikaru; Taki, Yasuyuki; Hashizume, Hiroshi; Sassa, Yuko; Nagase, Tomomi; Nouchi, Rui; Kawashima, Ryuta	2012	ii	iii	ii	-	i; iii	-	-
57	Mehta, Ravi; Zhu, Rui; Cheema, Amar	2012	i	iii	ii	i	i	-	iii
58	Berretta, Shirley; Privette, Gayle	1990	ii	iii	i	iv	iii	ii	-
59	Oppezzo, Marily; Schwartz, Daniel L	2014	i	iii	iv	iv	iii	ii	-
60	Colzato, Lorenza S; Szapora Ozturk, Ayca; Pannekoek, Justine Nienke; Hommel, Bernhard	2013	ii	iv	iv	iii	ii	-	
61	Bhagwatwar, Akshay; Massey, Anne; Dennis, Alan R	2013	ii	iv	iv	i	i	-	ii
62	Fonseca, Manuel J; Jorge, Joaquim A; Gomes, Mário R; Gonçalves, Daniel; Vala, Marco	2009	ii	iv	ii	i	i	-	ii
63	Lan, Li; Hadji, Sarra; Xia, Lulu; Lian, Zhiwei	2021	i	i	ii	i	iii	-	i

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