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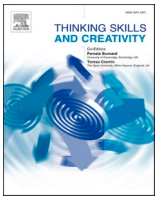

Relationships between physical environments and creativity: A scoping review

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ABSTRACT

Does the environment influence creativity? Several studies have reported that the physical environment can significantly impact creativity and innovation. While recognizing the multi-faceted characteristics and processes associated with creativity, this study identifies investigations in the literature that stress the positive effect of physical environment on individual and/or organizational creativity. This scoping review systematically investigates 33 relevant articles–searching for trends and front, research characteristics, and relationships between adult creativity and the physical environment. Creativity is conceptualized from three perspectives: creative thinking abilities, the potential for creative work performance, and how culture/climates stimulate creativity. Significant physical environments are categorized according to 15 physical attributes (i.e., light, furniture, visual stimulation, indoor plants, window, privacy, proximity, air quality, sounds, odors, volume, technical support, spatial variety, sense of control, and personal or cultural reflection), and seven spatial types (i.e., open spaces, social spaces, exploration zones, recharging spaces, mixed-use spaces, balanced layouts, and production labs) that support creativity. The creative press literature demonstrates that visual stimulation and social space constitute creative output's most significant physical aspects. The study discusses the identified relationships among specific creativity concepts and physical environmental elements and presents an agenda for future research.

1. Introduction

Creative press, which refers to the relationship between humans and their environment, is one of the four dimensions (the 4Ps: persons, process, press, and products) of creativity, according to Rhods (1961). The creative press represents the climate in which creative people perform or where creative processes and products are determined. Researchers from multiple disciplines have recognized that, beyond the perception that creativity is an individual gift, social and environmental influences impact creativity (Amabile, 2018; Amabile & Pillemer, 2012). Accordingly, there is a growing interest in environments that support creativity, including critical physical aspects of those environments. Scholars connected the physical environment with psychosocial factors that can influence creativity. For example, Support for Creativity in a Learning Environment (SCALE; Richardson & Mishra, 2018) comprises three foundational areas: learner engagement, physical environment, and learning climate. In one of the most prominent papers on

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creative learning environments, Davies et al. (2013) describe physical learning spaces designed to promote creative skills in children and young people as imaginative, resourceful, and supportive. Applied to work environments, the Creativity Development Quick Scan (CDQS), a checklist that analyzes the creativity support of the work environment (Dul & Ceylan, 2011), considers 21 elements of the work environment (nine socio-organizational and 12 physical dimensions).

Several studies addressed architectural categories that contribute to creativity, such as spatial layouts, spatial types, architectural details, locations, ambient conditions, etc., as well as physical attributes such as furniture, indoor plants, colors, materials, window views, daylight, positive sound and smell, etc. (Dul & Ceylan, 2011; Groves & Marlow, 2016; McCoy, 2005; Meinel et al., 2017). Although these documents discuss important physical elements of the work environment that promote creative performance, this information may be too broad or fragmented to apply to different situations. Attempting to identify which physical factors influence creativity in specific situations can help us gain a comprehensive understanding of the potential role of the physical environment in enhancing creativity. This can also guide practitioners, specifically concerning what spaces to include, how to design and manage them, and how they support goals regarding creativity. Considering that cognitively and perceptually stimulating surroundings may promote creativity (Amabile, 1996), studying the perceived elements of optimistic environments can also provide a physical framework for creativity.

Researchers widely define creativity as the ability to produce novel and valuable ideas (Lee et al., 2020; Runco & Jaeger, 2012). The definition suggests that creativity is somewhat subjective and socially determined. Studies that have examined the impact of the environment on creativity have found that an individual's surroundings can significantly influence whether they display (or are encouraged to display) their creative abilities to generate new and useful ideas (Runco & Jaeger, 2012; Treffinger et al., 2007). Scholars have established that multiple cycles of divergent and convergent thinking serve as creative abilities when generating new and alternative ideas to solve problems (Basadur, 1995; Lubart, 2001; Runco, 2007). In particular, researchers have often studied divergent thinking as it provides useful information about one's potential to produce original ideas during problem-solving (Runco, 2010; Runco & Acar, 2012). Divergent thinking focuses on generating original, flexible, and elaborate ideas, while convergent thinking involves judgment and evaluation as a moderator during the creative process (Cropley, 2006; Zhu et al., 2019). Despite the distinction between creative potential and actual creative output, researchers note that individuals cannot fulfill their creative potential in an inhibiting environment (De Alencar & De Bruno-Faria, 1997; Sternberg & Williams, 1996; Zhou & George, 2001). Meanwhile, organizational creativity refers to the creation of useful new ideas by a group of people working together (De Paoli et al., 2019; Kallio et al., 2015) as a result of social interaction, communication, and collaboration. Researchers usually consider organizational creativity as an outcome of organizational performance, which is closely linked to innovation phases. Creativity and innovation are often used interchangeably, but creativity is the seed of innovation (Amabile, 1996; Steidle & Werth, 2013). A supportive culture is particularly essential for achieving organizational creativity (Amabile & Pratt, 2016; Meinel et al., 2017), and the physical environment can reflect the ability and symbolic aspects of organizational creativity (De Paoli et al., 2019).

Scholars broadly study the physical environment's influence on perception and behavior to promote human well-being, productivity, and motivation (Blomberg & Kallio, 2022; Meinel et al., 2017). For example, McCoy (2005) reports that physical environments can provide opportunities for creatively associated behaviors in a paper linking physical work environments to creative contexts. Martens (2011) also delineated the activities related to various moments of creative thinking and how environmental settings sustained them. In a recent study, Blomberg & Kallio, 2022 reviewed the physical context of creativity concerning various behaviors and suggested that defining creative processes relevant to physical space and considering the occupants' experiences can connect the physical environment to creativity.

However, researchers have made few attempts to determine which aspects of creativity the environments support. The Wallas model (1926), one of the oldest and most widely accepted due to its broad but simple inclusion, may provide a practical way to connect dimensions of creativity with actual behaviors. It has four stages: 1) the preparation stage, where the problem is initiated and defined, 2) the incubation stage, where a deep understanding of the problem is sought, 3) the illumination stage, where potential solutions are explored, and 4) the verification stage, where solutions are evaluated and redefined. Using the Wallas model, Sailer (2011) distinguished behaviors at each stage of the creative cycle to propose varying spatial needs. The incubation and illumination stages, which require an intense focus on work, may benefit from private spaces that help individuals concentrate. Conversely, individuals working during the preparation and verification stages may benefit from communal spaces that provide the necessary higher levels of interaction. Although creative processes may require the proposed activities, understanding actual creative behaviors may vary as creative iterations are nonlinear and complex. Furthermore, there have been few studies on the relationship between the nonsequential nature of the creative process and environmental support (Haner, 2005; Martens, 2011).

While there is increasing attention on creative interiors to inspire occupants, few studies have examined the relationship between adult creativity and the environment that supports it. As adults encounter broader social contexts and challenges with spending much more time indoors, understanding the relationship between the physical environment and adult creativity can promote professional advancement and sustainable societal growth (Levinson, 1986). The current study aims to identify matching physical environments that enhance various dimensions of adult creativity. Despite several literature reviews of the relationship between environments and creativity, there is a need to clarify key concepts in the current literature on the physical context of creativity through a scoping review. The research questions are:

(1) From a macro perspective, what empirical research trends and relationships between studies in the existing literature on physical environments support adult creativity? What are the yearly trends, journals/research area, country performance/collaboration, and keyword network?

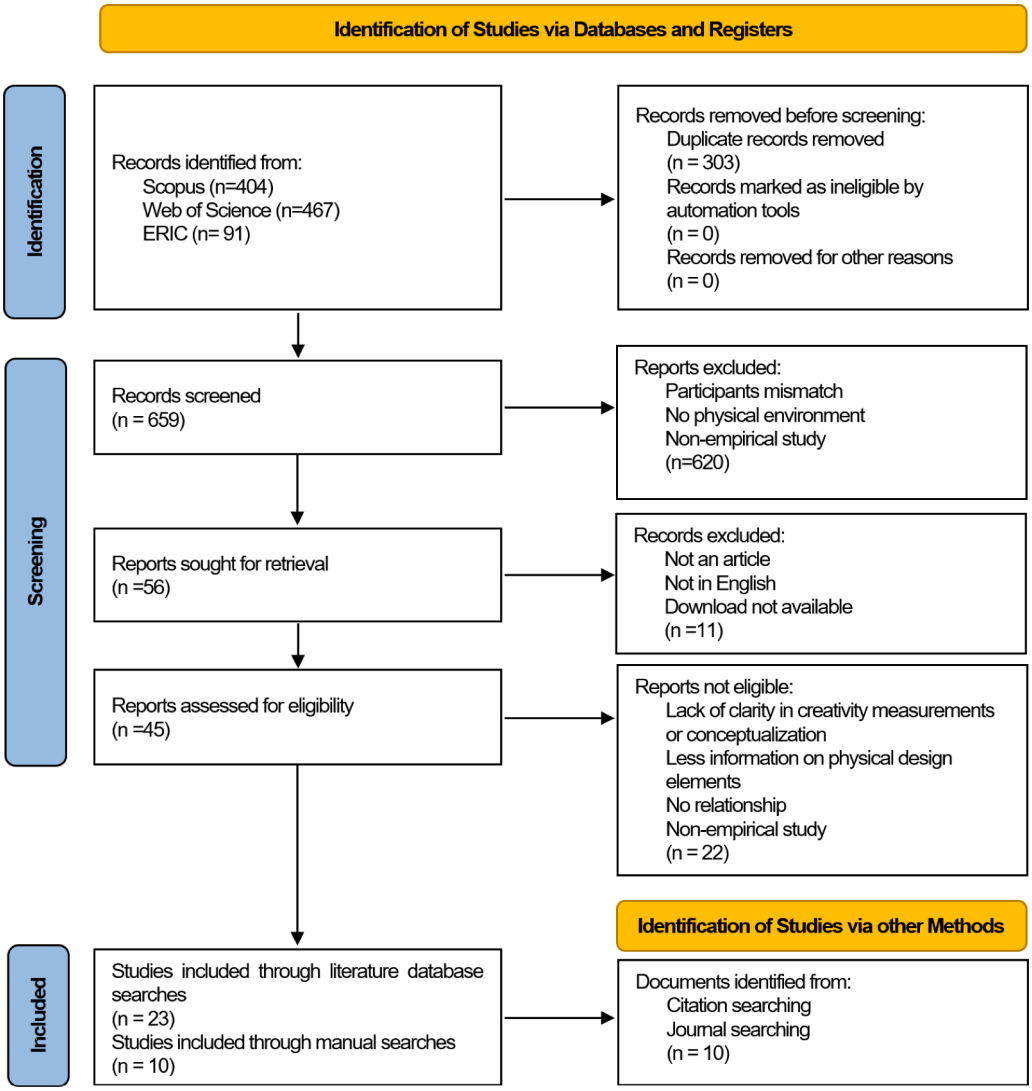

Fig. 1. PRISMA protocol for sampling.

(2) While examining each study, what are the research characteristics? What are the research objectives, research strategies (design), data collection and analysis techniques, participants, physical environmental factors, and creativity conceptualization/measurement of the literature?
(3) Synthetically, which physical attribute types and qualities did the researcher discuss concerning certain creativity concepts in the existing literature?

This overview of empirical research evidence can inform future research agendas that address detailed spatial affordances and promote refined creative behaviors and better design solutions.

2. Methodology

A systematic search for and review of the relevant literature identified the following: (1) research trends in the study of relationships among physical environments and creativity, (2) the characteristics of studies, methods, and variables, and (3) the relationships among physical environments and various concepts of creativity.

2.1. Search and strategy

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol was followed to review relevant articles (Moher et al., 2009). The Scopus, Web of Science, and the Education Resources Information Center (ERIC) academic databases

were used to identify precedent studies on physical spaces that support creativity during the identification stage. Scopus and Web of Science are the largest abstract and citation databases of peer-reviewed research literature in sciences, social sciences, arts, and humanities. ERIC is an online digital library of education research and information. The literature search was conducted on April 22, 2021 using the following search words: ("creativity" OR "creative thinking" OR "creative behavior*") AND ("physical environment*" OR "physical space*" OR "environmental factor*" OR "environmental attribute*" OR "environmental characteristic*" OR "spatial") AND ("influence*" OR "support*" OR "stimulate*" OR "impact*" OR "effect*" OR "affect*"). While some previous reviews (Clark et al., 2007; Laursen et al., 2014) conducted their study of the influence of the environment with specific search terms (e.g., open space, light, color), this study used more general keywords regarding "physical environment" to recognize the environmental factors. According to the data "title, abstract, keyword," 404 results on Scopus, 467 on Web of Science, and 91 on ERIC were found. Of the 962 searched works, 303 overlapping articles were removed.

During the screening stage, 56 articles out of the 659 unique works were selected by filtering out those that did not meet the following requirements:

(i) Participants were adults: those with "college students," "young adults," "adults," or "employees" were included; those with "a child," "children," or "adolescents" were excluded.
(ii) Physical setting: no specific limitation, but likely within any interior environments; those with no "physical environment" were excluded.
(iii) Empirical study: "surveys," "observations," "case studies," or "interviews," etc. were included; "literature reviews," "personal observations," "commentaries," etc. were excluded.

By setting the data type as "article" and the language as "English," the study included 47 articles from this initial abstract screening. A total of three reviewers participated in the screening process, including the authors of this article and a reviewer. The three reviewers independently examined the title, abstract, and keywords and worked on the screening process. Then, each individual voted "yes," "no," or "maybe." In the case of articles with conflicting opinions, the reviewers examined the full text to determine eligibility.

In the next step, the three reviewers joined the final screening process to determine whether each article contained: 1) clarification of physical environmental aspects and concepts related to creativity, and 2) the positive impact of physical environmental variables on creativity. The reviewers excluded studies lacking physical aspects and null relationships between physical environments and creativity. From these, the full-text screening of the 45 downloadable original manuscripts finally selected 23 articles for the study.

Additionally, a manual search was conducted to identify further relevant studies that automatic database searches cannot find. The reviewers added eight articles by reviewing the cited papers in the 23 selected manuscripts from the previous stage. They found two articles published in the journals searched with the terms "creativ*" and "innovation" in searching Journal Citation Reports (JCR). The three reviewers participated in the process of searching the additional journals and articles.

Ultimately, 33 research papers—23 selected through academic literature database searching and 10 through hand searching—were deemed relevant to the current study. Fig. 1 depicts the PRISMA in this study, including details on the inclusion and exclusion processes.

2.2. Bibliometrics

For bibliometrics, the Bibliometrix R Package (Aria & Cuccurullo, 2017) and VOSviewer (Van Eck et al., 2010) were used to measure scientific domain evolution, the impact of scholarly publications, and the process of scientific knowledge production. These programs allowed the current research to analyze the global trend in physical environment studies for creativity by examining the publication year, country of publication and the number of citations generated in that country, and journal article keywords. When analyzing author keywords (which were chosen by the authors to reflect the article content), the first round of the keywords co-occurrence network (KCN) analysis organized the author keywords, then filtered hyphens or plural terms. It also merged keywords into a single word when it encountered an identical concept. Additionally, a cluster analysis was used to visualize the research articles' structure.

2.3. Synthesizing study findings

Understanding the relationships between physical environments and creativity began by categorizing and synthesizing the physical element characteristics and the concepts of creativity in the 33 studies selected. Initially, the physical environment's types and qualities that positively influenced creativity were listed. Based on the 12 physical elements of the work environment in the Creativity Development Quick Scan (CDQS; Dul & Ceylan, 2011) and previous studies' categories of physical characteristics for fostering creativity (De Paoli et al., 2019; Lee, 2016; Martens, 2011; McCoy & Evans, 2002), this research structured the environmental design results and spatial features that supported creativity as described in the literature. Moreover, the thematic analysis method was used to identify the creativity pattern from diverse perspectives studied and reported in the existing literature (Isaksen & Akkermans, 2011; Lee et al., 2020). The thematic analysis identified how scholars understood creativity by reviewing the dimensions of each study's creative outcomes. The initial deductive codes of the outcomes were listed based on a careful review, then the dimensions were sorted into overarching codes and themes as concepts of creativity, using the languages related to the original articles. Finally, the present study linked the potential impact of interior design elements to the concepts of creativity.

Table 1
Number of annual publications by year.

Year	f	Year	f	Year	f	Year	f
1994	1	2008	1	2013	3	2017	1
2002	1	2009	1	2014	2	2019	3
2003	1	2011	3	2015	2	2020	7
2005	2	2012	1	2016	2	2021	2

Table 2
Keywords cluster and occurrences.

Cluster	Keywords
1	Work environment (7), corporate culture (3), creative ability in business (2)
2	Creativity (11), innovation (4), physical space (3)
3	Creative ability (3), interior decoration (2)
4	Office design (2), workspace (4)

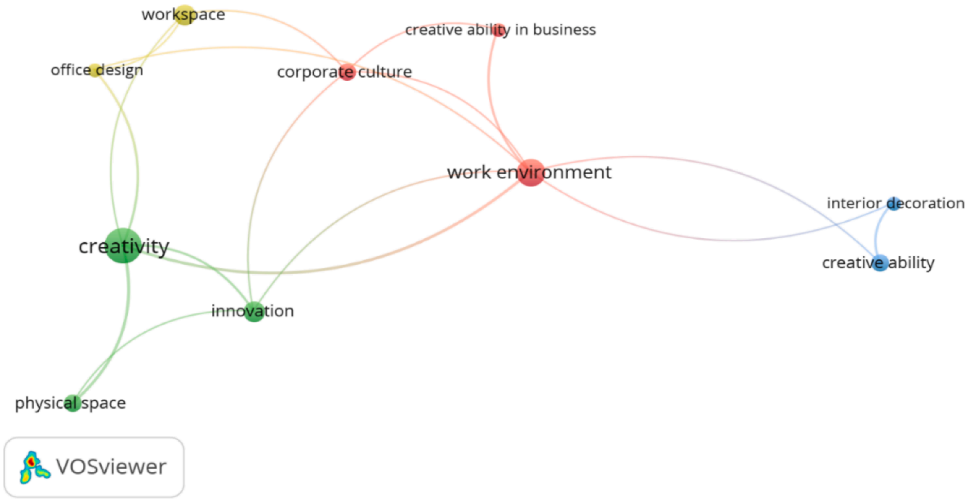

Fig. 2. Keywords network.

3. Results

This study reviewed 33 articles on physical environments that support creativity. As general characteristics of the sample studies, Bibliometrics examined the publication year, the published journal's field of study, the country of publication, and keywords. The authors of this research then analyzed the study's focus, research design, data collection methods, samples and settings, and significant findings. Finally, relationships between physical environmental features and specific facets of creativity were identified.

3.1. General research trends

3.1.1. Performance by year

The publication years of this study's 33 articles were between 1994 and 2021. Of the seven articles published in 2020, notably, six studied the effects of educational spaces on students. Table 1 shows that the number of published articles was less than five between 1994 and 2019 but soared in 2020 and after.

3.1.2. Journals

The sample articles used in this study represented 23 journals. The most frequently published journals were "Creativity and Innovation Management" and "Facilities," with four articles each. In addition, three studies were published in the "Journal of Environmental Psychology." Most articles were in management (13), followed by psychology (5), multi-disciplinary (5), environmental studies (4), ergonomics (4), and education (4) categories. Details are presented in the table (Appendix A).

3.1.3. Country

Out of all 33 articles, the United States (9) and Germany (5) had the highest number of publications, but all of them were single-

Table 3
Physical environments that stimulate creativity.

Category		Description	Sources
Physical Attributes	Light	The amount, quality, and type of light (including daylight) in the environment	Lan et al., 2021; Hoff & Oberg, 2015; Lukersmith & Burgess-Limerick, 2013; Steide & Werth, 2013; Ceylan et al., 2008
	Furniture	The quality and configuration of furniture (e.g., chairs, tables) in the environment	Hoff and Oberg, 2015; Knight & Baer, 2014
	Visual stimulation	Visual detail in the interior environment (e.g., colors, materials, high/low complexity of the elements, unconventional shapes or forms of interior elements)	Wu et al., 2021; Wagner & Growe, 2020; De Paoli et al., 2019; Hoff & Oberg, 2015; Ceylan et al., 2008; McCoy & Evans, 2002
	Indoor plants	The presence of natural plants or flowers in the environment	Ceylan et al., 2008; McCoy & Evans, 2002
	Window	The presence of windows and having visual access through windows placed in the environment	Hoff & Oberg, 2015; Lukersmith & Burgess-Limerick, 2013; Ceylan et al., 2008; McCoy & Evans, 2002
	Privacy	Avoiding the presence or view of others	Zhou et al., 2020; Hoff & Oberg, 2015; Lukersmith & Burgess-Limerick, 2013
	Proximity	The possibility of being close to others and sharing the physical environment	Bouncken & Aslam, 2019; De Paoli et al., 2019; Kallio et al., 2015; Sailer, 2011; Vithayanthawornwong et al., 2003
	Air quality	The indoor air quality (e.g., temperature, humidity, velocity)	Sicotte et al., 2019; Lukersmith & Burgess-Limerick, 2013
	Sounds	Positive sounds and the level of noise	Lukersmith & Burgess-Limerick, 2013; Mehta et al., 2012
	Odors	Positive odors	Lukersmith and Burgess-Limerick, 2013
	Volume	The size, width, and ceiling height of the environment	Chan & Nokes-Malach, 2016; McCoy & Evans, 2002
	Technical support	The availability of high and low-tech infrastructure for any activities in the environment	De Paoli et al., 2019; Lee, 2016; Oksanen & Stahle, 2013; Ceylan et al., 2008
	Spatial variety	Various space types (e.g., communication and concentration spaces)	Sicotte et al., 2019; Martens, 2011
	Sense of control	The degree of autonomy to choose and explore the environmental condition	Hoff & Oberg, 2015; Martens, 2011; Vithayanthawornwong et al., 2003
	Personal or Cultural reflection	Decorative elements or visual cues that remind one of their cultural history, value, or personality	De Paoli et al., 2019; Oksanen & Stahle, 2013; Martens, 2011
Spatial Types	Open spaces	Common disengaged spaces for serendipitous interactions in the atrium, stairs, hallways, corners, or other paths	Storvang & Nguyen, 2020; Wagner & Growe, 2020; De Paoli et al., 2019
	Social spaces	Social and learning spaces that support informal/formal knowledge sharing, including particular gathering places (cafes, kitchens, library) and formal presentation rooms	Chi et al., 2021; Pittaway et al., 2020; Soares et al., 2020; Storvang & Nguyen, 2020; Bouncken & Aslam, 2019; Schmidt & Brinks, 2017; Lee, 2016; Hoff & Oberg, 2015; Kallio et al., 2015; Oksanen & Stahle, 2013; Martens, 2011; Sailer, 2011; Magadley & Birdi, 2009; Haner, 2005
	Exploration zones	Incubation spaces with resources and equipment that support Idea-generation (e.g., brainstorming, doodling)	Pittaway et al., 2020; Storvang & Nguyen, 2020; Hoff & Oberg, 2015; Haner, 2005
	Recharging spaces	Spaces that reduce stress and promote well-being through a break	Martens, 2011; Magadley & Birdi, 2009; Vithayanthawornwong et al., 2003
	Mixed-use spaces	Modifiable spaces that allow a versatile range of activities	Storvang & Nguyen, 2020; Wanqing et al., 2020; Oksanen & Stahle, 2013
	Balanced layouts	Spatial layouts that provide a balance between work (activity) modes	De Paoli et al., 2019; Lee, 2016; Martens, 2011; Sailer, 2011
	Production labs	Experimentation labs for playful creation and rapid prototyping	Haner, 2005; Pittaway et al., 2020; Schmidt & Brinks, 2017

Table 4
Conceptualization of creativity.

Concepts		Description	Sources
Creative thinking abilities	Divergent thinking	"the ability to generate as many ideas and responses to a problem as possible" that plays a key role in idea generation	Chan & Nokes-Malach, 2016; Lan et al., 2021; McCoy & Evans, 2002; Steide & Werth, 2013; Wu et al., 2021
	Convergent thinking	"the ability to integrate and synthesize various concepts into ideas" that identifies the best solution to a particular problem	Mehta et al., 2012; Wu et al., 2021
	Creative idea generation	The generation of new ideas and articulation of creative ideas	Lee, 2016; Magadley & Birdi, 2009; Oksanen & Stahle, 2013; Zhou et al., 2020
Creative performance	Individual creative performance	The extent to which "employees can produce novel and potentially useful ideas" for their tasks and also the implementation of ideas at the professional level	Ceylan et al., 2008; Hoff & Oberg, 2015; Lukersmith & Burgess-Limerick, 2013
	Team creative performance	The team capacity or team viability to achieve novel and valuable processes/products based on the shared goals	Knight & Baer, 2014; Sicotte et al., 2019
Organizational climate to stimulate creativity	Social gathering and informal knowledge exchange for creative culture	The creative atmosphere to share a common understanding that leads to collaboration and innovation without a social barrier; this views knowledge generation and transmission as social processes	Bouncken & Aslam, 2019; De Paoli et al., 2019; Kallio et al., 2015; Pittaway et al., 2020; Schmidt & Brinks, 2017; Soares et al., 2020; Storvang & Nguyen, 2020; Wagner & Growe, 2020
	Encouraging various activities for different phases of the creative process (Wallas model)	The context that supports diverse thoughts and actions as a creative process; motivates people to symbolize innovation and signal creativity; and promotes the 'flow' of creative work	Chi et al., 2021; Haner, 2005; Martens, 2011; Sailer, 2011; Vithayanthawornwong et al., 2003; Wanqing et al., 2020; Wu et al., 2021

Table 5
Relationship between the physical environment and creative thinking.

Creative outcomes	Physical environment	
Higher divergent thinking	Light	Bright warm lighting (Lan et al., 2021)
		Standard warm lighting (Lan et al., 2021)
		Bright cool lighting (Lan et al., 2021)
		Dim lighting (Steide & Werth, 2013)
	Visual stimulation	Roundedness of furniture and equipment (Wu et al., 2021)
	Volume	Large room with a high ceiling (Chan & Nokes-Malach, 2016; McCoy & Evans, 2002)
Higher convergent thinking	Visual stimulation	Angular forms of furniture and equipment (Wu et al., 2021)
	Sound	Moderate noise (Mehta et al., 2012)
Creative idea generation	Visual stimulation	Unusual materials (Wagner & Growe, 2020)
	Privacy	Private meeting room (Zhou et al., 2020)
	Technical support	Smartness (hybrid work support) (Oksanen & Stahle, 2013)
		Low- and high-tech support (Lee, 2016)
	Personal reflection	Value reflecting (Oksanen & Stahle, 2013)
	Social spaces	Common spaces for communication (Oksanen & Stahle, 2013)
		Interactive areas for team collaboration (Magadley & Birdi, 2009)
		Spaces for idea generation (formal, informal, and impromptu meeting spaces) (Lee, 2016)
	Exploration zones	Resource rooms for inspiration (Magadley & Birdi, 2009)
		Workroom for brainstorming (Magadley & Birdi, 2009)
	Recharging spaces	Recharging spaces for mental breaks (Lee, 2016)
	Mixed-use spaces	Modifiability for a versatile range of activities (Oksanen & Stahle, 2013)
	Balanced layouts	Balance among work modes (Lee, 2016)

country publications (SCPs), meaning there was minimal international collaboration. There were only five Multiple Country Publications (MCPs): two from China, one each from the Netherlands, Denmark, and Norway. This finding suggests that studies have usually been conducted internally rather than through international cooperation.

The number of citations per country and the average number of citations were calculated by dividing the number of citations by a country's total number of publications. Although most articles originated in the United States, the Netherlands had the highest average value of citations per article (Appendix B).

3.1.4. Keyword analysis

Using the VOSviewer, cited keywords from the total number of keywords appearing in the database passed the set threshold value and were applied in the visual representation. Table 2 shows the ten keywords selected based on occurrence frequency and total link strength. The classified clusters are also shown based on the outcomes of keyword network analysis. The most frequently used keywords in articles were "creativity," "work environment," and "innovation."

The network analysis produced four clusters representing creative press, creativity and space, creativity and interior design, and

Table 6
Relationship between the physical environment and creative performance.

Creative outcomes	Physical environment	
Highly support (individual) creative performance	Light	Bright light (Ceylan et al., 2008)
		Consistent lighting (Hoff & Oberg, 2015)
		Available daylight (Hoff & Oberg, 2015)
		Daylight access (Lukersmith & Burgess-Limerick, 2013)
	Visual stimulation	Complex spatial forms (McCoy & Evans, 2002)
		Low complexity (Ceylan et al., 2008)
		Natural materials (McCoy & Evans, 2002)
		Natural surroundings (De Paoli et al., 2019)
		Inspirational design (Hoff & Oberg, 2015)
		Cool colors (Ceylan et al., 2008)
	Volume	High ceiling (McCoy & Evans, 2002)
	Plants	Presence of indoor plants (Ceylan et al., 2008; McCoy & Evans, 2002)
	Window	Presence of windows (Ceylan et al., 2008; Hoff & Oberg, 2015; McCoy & Evans, 2002)
		View to nature; any window view (Lukersmith & Burgess-Limerick, 2013)
	Technical support	Future technology (De Paoli et al., 2019)
		Computers (Ceylan et al., 2008)
	Privacy	Private room (Hoff & Oberg, 2015; Lukersmith & Burgess-Limerick, 2013)
	Air quality	Good indoor air quality (Lukersmith & Burgess-Limerick, 2013)
	Sound	Decreased noise (Lukersmith & Burgess-Limerick, 2013)
		Positive sounds (Lukersmith & Burgess-Limerick, 2013)
	Odors	Positive smell (Lukersmith & Burgess-Limerick, 2013)
	Sense of control	Controllable lighting (Hoff & Oberg, 2015)
	Furniture	Ergonomic furniture (Hoff & Oberg, 2015)
	Social spaces	Informal social spaces (Hoff & Oberg, 2015)
	Exploration zone	Inspirational spaces for brainstorming (Hoff & Oberg, 2015)
	Recharging spaces	Stress managing spaces (Hoff & Oberg, 2015)
Higher team creative performance	Furniture	Non-sedentary configuration (Knight & Baer, 2014)
	Air quality	Good indoor air quality (Sicotte et al., 2019)
	Spatial variety	Various space types (Sicotte et al., 2019)

workplace factors. Fig. 2 illustrates these clusters in different colors, with cluster 1 (in red) containing "work environment" and cluster 2 (in green) containing "creativity" and "innovation." The clusters were distinct from each other, with each one playing a significant role in the network.

3.2. Sample characteristics

3.2.1. Focus of the study

The three major research objectives were to: (1) examine the relationships between environmental design elements and creativity, (2) identify the characteristics of spaces intentionally designed to promote creative behaviors or innovation, and (3) explore the influences of specific spatial attributes on creativity as perceive by user groups. The literature included in Focus 1 ($n = 9$) investigated particular settings using standardized creativity tests. In Focus 2 ($n = 8$), articles primarily included case studies conducted in innovative labs. The studies in Focus 3 ($n = 16$) employed various approaches to investigate relationships among existing environments and users. Studies that measured the indirect impact of physical environments on creativity (e.g., higher communication level or productivity success, etc.) were excluded. The general information deduced from the studies is presented using these three focus areas (Appendix C).

3.2.2. Research design

The 33 research articles employed various research designs: 23 descriptive studies, eight experimental studies, one explanatory study, and one mixed design (i.e., experimental and descriptive). Most descriptive studies focused on identifying physical environment characteristics that support creativity, using single or multiple cases. Experimental studies examined the role of specific environmental cues in creative tasks. The one explanatory study attempted to explain why innovation labs receive attention (Lewis & Moultrie, 2005), while the one mixed design study included a series of descriptive and experimental studies on interior design elements that influence creativity (McCoy & Evans, 2002).

3.2.3. Data collection methods

About half of the studies employed multiple methods to collect data, especially case studies. Interviews ($n = 16$) and surveys ($n = 9$) appeared most frequently, but some studies employed standardized creativity tests ($n = 9$). In addition, five studies used observations, three used site visits, two used space syntax, and one used visual descriptions as the primary data collection method.

3.2.4. Participants

The majority of study participants were either working professionals ($n = 20$) or undergraduate/graduate students ($n = 9$). One study included both working professionals and students (Wu et al., 2021), while three other studies observed facilities without any

Table 7
Relationships between the physical environment and creative climates.

Creative outcomes	Physical environment	
Social gathering and informal knowledge exchange for creative culture	Proximity	Close to team members (De Paoli et al., 2019; Vithayanthawornwong et al., 2003)
		Combined circulation (Kallio et al., 2015)
		Co-location (Bouncken & Aslam, 2019)
	Personal/cultural reflection	Culturally aligned symbols (De Paoli et al., 2019)
	Open spaces	Playfully or artistically designed open spaces (De Paoli et al., 2019)
		Open spaces with visual access (Storvang & Nguyen, 2020)
		Open spaces for a familiar/interesting atmosphere (Wagner & Growe, 2020)
	Social spaces	Interdisciplinary environment for knowledge exchange (Storvang & Nguyen, 2020)
		Community-gathering places (cafes, library, seating opportunities, playground) (Kallio et al., 2015; Soares et al., 2020)
		Common spaces, more interactive spaces (Kallio et al., 2015)
		Social and learning spaces (Bouncken & Aslam, 2019)
		Ideation spaces for idea sharing with social elements (Pittaway et al., 2020)
		Integrative spaces to connect all resources (Pittaway et al., 2020)
		Open innovation labs for professional communities (Schmidt & Brinks, 2017)
	Exploration zone	Incubation spaces with flexible configurations and programming (Pittaway et al., 2020)
		Driven spaces for trying out different professional opportunities (Storvang & Nguyen, 2020)
	Mixed-use spaces	Semi-open spaces for multiple uses (restaurant, meeting, event, exhibition, etc.) (Storvang & Nguyen, 2020)
	Balanced layouts	Balanced spaces between individual and collective; professional and inherent; and planned and emerging creativity (De Paoli et al., 2019)
	Production labs	Experimentation labs for playful creation and idea implementation (Schmidt & Brinks, 2017)
		Investor-driven labs to transform ideas into business models (startups) (Schmidt & Brinks, 2017)
		Labs for rapid prototyping (Pittaway et al., 2020)
Encouraging various activities for different phases of the creative process (Wallas model)	Visual stimulation	Roundedness of furniture and equipment (Wu et al., 2021)
	Proximity	Sharing circulation (Sailer, 2011)
	Spatial variety	Various space types (Martens, 2011)
	Sense of control	Sense of control (Martens, 2011; Vithayanthawornwong et al., 2003)
	Personal reflection	Personal or cultural reflection (Martens, 2011)
	Social spaces	Informal social spaces for communication and concentration (Chi et al., 2021; Martens, 2011)
		Common facilities (Sailer, 2011)
		Interaction spaces with unusual structures (Haner, 2005)
		Explorational spaces for small groups (Haner, 2005)
		A consensus court to make decisions (Haner, 2005)
	Recharging spaces	Spaces for relaxation (Martens, 2011)
		Stretch-out facilities and break areas (Vithayanthawornwong et al., 2003)
	Mixed-use spaces	Connecting different needs of creative behaviors (Wanqing et al., 2020)
	Balanced layouts	Balance of communal and private spaces (Sailer, 2011)
		Balance between communication and concentration (Martens, 2011)
	Exploration zone	Retreat zone for privacy and individual adjustment (Haner, 2005)
	Production labs	A production patio (Haner, 2005)

occupants (De Paoli et al., 2019; Haner, 2005; Soares et al., 2020). The number of participants varied depending on the data collection method, with smaller numbers (4 to 40) for studies using semi-structured or in-depth interviews (Pittaway et al., 2020; Schmidt & Brinks, 2017) and larger numbers (645 employees or 16 to 330 university students) for surveys (Mehta et al., 2012; Sicotte et al., 2019).

3.2.5. *Settings*

The research articles' most frequently used physical settings were workplaces ($n = 25$). Notably, five were in university offices (Chan & Nokes-Malach, 2016; Knight & Baer, 2014; Lan et al., 2021; Steidle & Werth, 2013; Stone & Irvine, 1994), four made use of organizations' creative labs (Haner, 2005; Lewis & Moultrie, 2005; Magadley & Birdi, 2009; Schmidt & Brinks, 2017), and three explored changes in creative behaviors after a firm relocated (Kallio et al., 2015; Sicotte et al., 2019; Vithayathawornwong et al., 2003). Of the studies that investigated learning environments, five took place in public spaces of universities (McCoy & Evans, 2002; Mehta et al., 2012; Soares et al., 2020; Wanqing et al., 2020; Zhou et al., 2020) and three articles described the characteristics of innovative spaces in universities (Oksanen & Stahle, 2013; Pittaway et al., 2020; Wu et al., 2021).

3.2.6. *Significant physical environments*

This study explored and categorized physical environments that stimulate creativity into 15 interior design elements (light,

furniture, visual stimulation, indoor plants, window, privacy, proximity, air quality, sounds, odors, volume, technical support, spatial variety, sense of control, and personal or cultural reflection) and seven types of spaces (open spaces, social spaces, exploration zones, recharging spaces, mixed-use spaces, balanced layouts, and production labs) (Table 3).

3.2.7. Creativity conceptualization

The reviewed articles conceptualized the impact of spatial characteristics on creativity from three perspectives: examining creative thinking abilities, identifying the potential for creative performance at work, and organizing the culture/climate to stimulate creativity (Table 4). The articles examining creative thinking abilities focused on divergent thinking, convergent thinking, or idea-generation capacity. Others investigated the potentials for creative performance by looking at self-perception while subjects engaged in individual or team tasks. A few studies focused on organizational strategies that evoked creativity, such as contextualizing creativity through the outcomes of a social process or the presence of motivational culture for creative activities. The table in Appendix D summarizes the coding process of this analysis.

3.2.8. Creativity measurement

Researchers who conducted the selected studies identified creativity in unique ways. For dependent variables, they employed a variety of standardized creative thinking tests such as the Torrance Tests of Creative Thinking (TTCT) and the Alternative Uses Test (AUT) for divergent thinking or the Remote Associates Test (RAT) for convergent thinking (e.g., Chan & Nokes-Malach, 2016; Lan et al., McCoy & Evans, 2002; Wu et al., 2021). Other studies relied heavily on creative environmental affordance perception through surveys or interviews with users in a specific setting. In this case, participants self-rated their creative potential (e.g., Chi et al., 2021; Lukersmith & Burgess-Limerick, 2013) or evaluated their organizations' support of creativity (e.g., Martens, 2011; Storvang & Nguyen, 2020). A few studies focused on given behaviors using observational methods, searching for interaction patterns (e.g., Bouncken & Aslam, 2019; Soares et al., 2020) or activities consistent with the Wallas creative process model (e.g., Haner, 2005; Sailer, 2011).

3.3. Relationship between the physical environment and creativity in context

This study concluded by presenting the relationships between concepts of creativity and significant physical environments. Based on different conceptualizations of creativity, Tables 5, 6, and 7 show the essential design factors that support creativity in the literature.

3.3.1. Higher creative thinking abilities

Studies that focused on improved divergent thinking, convergent thinking, or idea generation reported positive relationships among various visual stimulations in the environment and spatial types (Table 5). Particularly, higher divergent thinking scores were associated with rounded interior features, interior lighting conditions, and large rooms with high ceilings (Chan & Nokes-Malach, 2016; Lan et al., 2021; McCoy & Evans, 2002; Steide & Werth, 2013; Wu et al., 2021). Convergent thinking was positively impacted by angular environmental forms (Wu et al., 2021) and moderate noise levels (Mehta et al., 2012). A greater number of creative ideas were generated when the environment included unusual materials (Wagner & Growe, 2020), private collaborations (Zhou et al., 2020), technical support (Lee, 2016; Oksanen & Stahle, 2013), and personal value reflection (Oksanen & Stahle, 2013). Further, various space types were also considered inspirational for creative idea generation: social, exploration, recharging, and mixed-used spaces with balanced workplace layouts (Lee, 2016; Magadley & Birdi, 2009; Oksanen & Stahle, 2013).

3.3.2. Higher creative performance

The literature included information on the relationship between the physical environment and creative performance at individual and group levels (Table 6). "Visual stimulation" was the category that appeared most often in support of individual creative performance, including complex forms and details, natural materials, inspirational design, and cool interior space colors. Bright or consistent lighting and daylight supported individual creative performance. In addition, high ceilings, the presence of interior plants and windows, views of nature, technology, private rooms, sound and odor quality, controllable lighting, and ergonomic furniture all facilitated individual creative performance (Ceylan et al., 2008; De Paoli et al., 2019; Hoff & Oberg, 2015; Lukersmith & Burgess-Limerick, 2013; McCoy & Evans, 2002). In particular, Hoff and Oberg (2015) suggested spatial types for individual creative work performance that include informal social, inspirational and stress management spaces. Studies also suggested non-sedentary furniture configuration (Knight & Baer, 2014), good indoor air quality, and spatial variety (Sicotte et al., 2019) for maximal team creative performance.

3.3.3. Organizational climate to stimulate creativity

Many studies discussed the physical environment's potential role in instigating a creative culture within an organization. The focus was twofold: 1) an interactive environment is essential for information gathering and knowledge exchange, and 2) a motivational climate encourages various activities for creative processing (Table 7). Studies recommended impromptu collaborations with a focus on providing spaces designed to bring individuals close to others, thus producing a boost in creativity (Bouncken & Aslam, 2019; De Paoli et al., 2019; Kallio et al., 2015; Vithayanthaworn et al., 2013) and cultural reflection (De Paoli et al., 2019). Researchers discussed various spatial types that support social interactions: open spaces (De Paoli et al., 2019; Storvang & Nguyen, 2020; Wagner & Growe, 2020), social spaces (Bouncken & Aslam, 2019; Kallio et al., 2015; Pittaway et al., 2020; Schmidt & Brinks, 2017; Soares et al., 2020; Storvang & Nguyen, 2020), exploration zones (Pittaway et al., 2020; Storvang & Nguyen, 2020), mixed-use spaces (Storvang &

Appendix A
Categories of the sources.

Source	f	Edition	Category
Creativity and Innovation Management	4	SSCI	Management
Facilities	4	ESCI	Management
Journal of Environmental Psychology	3	SSCI	Psychology, multi-disciplinary, environmental studies
Ergonomics	2	SSCI, SCIE	Ergonomics, psychology, engineering, industrial
Journal of Knowledge Management	2	SSCI	Psychology, educational
Bottom Line	1	ESCI	Information science & library science
Building Simulation	1	SCIE	Thermodynamics, construction & building technology
Creativity Research Journal	1	SSCI	Psychology, multi-disciplinary, psychology, educational
Human Factors and Ergonomics In Manufacturing	1	SSCI, SCIE	Ergonomics, engineering, manufacturing
Interactive Learning Environments	1	SSCI	Education & educational research
International Journal of Entrepreneurial Behavior and Research	1	SSCI	Business, management
International Journal of Human–Computer Studies	1	SSCI, SCIE	Psychology, multi-disciplinary, ergonomics, computer science, cybernetics
International Journal of Human Resource Management	1	SSCI	Management, engineering, manufacturing
Journal of Consumer Research	1	SSCI	Business
Journal of Corporate Real Estate	1	ESCI	Management
Journal of Creative Behavior	1	SSCI	Psychology, educational
Journal of Interior Design	1	AHCI	Architecture
Journal of Management and Organization	1	SSCI	Management
Journal of Problem Solving	1	SSCI	Education & educational research
Journal of Product Innovation Management	1	SSCI, SCIE	Business, management, engineering, industrial
Spatial Research and Planning	1	ESCI	Geography
Social Psychological and Personality Science	1	SSCI	Psychology, social
Sustainability	1	SSCI, SCIE	Environmental studies, green & sustainable science & technology, environmental sciences

Appendix B
Performance of country.

Country	f	SCP	MCP	Total Citation	Citation per Article
United States	9	9	0	348	38.67
Germany	5	5	0	87	17.40
United Kingdom	4	4	0	78	19.50
Netherlands	3	2	1	156	52.00
China	3	1	2	3	1.00
Finland	2	2	0	69	34.50
Australia	1	1	0	10	10.00
Canada	1	1	0	4	4.00
Sweden	1	1	0	14	14.00
Taiwan	1	1	0	0	0.00
Turkey	1	1	0	0	0.00
Denmark	1	0	1	1	1.00
Norway	1	0	1	4	4.00

The journals' country of origin depends on the affiliation of the corresponding authors.
Abbreviations: SCP, Single Country Publications; MCP, Multiple Country Publications.

Nguyen, 2020), and production labs (Pittaway et al., 2020), including balanced layouts (De Paoli et al., 2019).

Another significant consideration in creating an atmosphere that encourages creativity involved different environmental support for different phases of the creative process. Since distinct creative process steps require specific activities, spatial variety is essential to reinforce behaviors (Martens, 2011; Wanqing et al., 2020). Specifically, Haner (2005) and studies oriented toward creative climates have shown that supportive office design can facilitate employee motivation to implement several loops of convergent and divergent thinking during the creative process (Martens, 2011; Sailer, 2011). The most often appearing attributes in the literature included various balanced space layouts such as social, recharging, mixed-use, and exploration spaces, as well as production labs (Chi et al., 2021; Haner, 2005; Martens, 2011; Sailer, 2011; Vithayanthawornwong et al., 2003; Wanqing et al., 2020).

4. Discussion

This study provides evidence that the physical environment plays a potential role in fostering creativity through a scoping review of 33 research articles. This review revealed trends in the creative press literature, research characteristics, and relationships between

Appendix C
General information of the studies.

Source	Objective	Research design	Participants	Physical setting	Creativity
Focus 1. Examining the relationship between environmental design elements and creativity					
Lan et al. (2021)	Examined the effects of lighting illuminance and color temperature on creative thinking	Experimental	24 undergraduate students (Shanghai)	Private offices at university: illuminance · lighting colors	Figural creativity (TTCT); Verbal creativity (AUT); Analytical tasks
Zhou et al. (2020)	Examined the role of spatial and material context in generating ideas for a creative task	Experimental	16 graduate students (U.S.)	Collaborative spaces at university: spatial (private room vs. common area) · material (pen-paper vs. tablet)	A toy design task as a team
Chan & Nokes-Malach, 2016	Examined divergent thinking and creative problem-solving scores in different sizes of rooms	Experimental	156 students (graduate/ undergraduate) & university employees (U.S.)	Offices and auditoriums at university: different spatial volumes	AUT; Shape invention task; RAT; Letter series task
Knight and Baer (2014)	Examined the influences of non-sedentary arrangements on group performance for a creative task	Experimental	214 undergraduate students (U.S.)	Conference rooms at university: sedentary workspace configuration	A team video creation task
Steidle and Werth (2013)	Examined the effects of light and darkness on creativity	Experimental	313 undergraduate students (Germany)	Seminar rooms and offices at university: different levels of illuminance	AUT; Structured imagination task; Connecting-dot task; Creative insight problems
McCoy and Evans (2002)	Investigated the role of specific design elements on creativity	Mixed (Descriptive and Experimental)	60 undergraduate students (U.S. & Canada)	75 interior images of social settings & two entrance foyers on campus	TTCT; A collage-making task
Wu et al. (2021)	Examined the effects of the shape of makerspaces on divergent and convergent creativity	Experimental	288 makers & 275 undergraduate students (China)	Spatial forms of Makerspaces (rounded vs. angular)	AUT; RAT; Approach/ avoidance motivation
Mehta et al. (2012)	Examined the effect of ambient noise levels on creative performance	Experimental	330 undergraduate students (Canada)	Lab settings and student lounge areas on campus	RAT
Stone and Irvine (1994)	Investigated the effects of window access on task types	Experimental	180 undergraduate students (U.S.)	Small offices at university: presence and view to windows	A divergent thinking task
Focus 2. Identifying the characteristics of spaces that intentionally designed for creative behaviors or innovation					
De Paoli et al. (2019)	Identified the spatial context of the office design to support employee creativity	Descriptive (Qualitative)	—	40 images of creative/ inspirational workspaces from search engines	Creativity through interactions
Oksanen and Stahle (2013)	Investigated the relevant attributes of physical spaces with innovation	Descriptive (Case study)	Seven user interviews (Finland)	Innovative spaces (three universities; Europe, Asia, & U.S)	Innovation as practices of new ideas
Magadley and Birdi (2009)	Observed the successful aspects of innovation labs to enhance organizational creativity	Descriptive (Case study)	68 employee surveys, 19 interviews, & field studies	Three innovation labs (one facility; U.K.)	Creative idea generation & collaboration
Haner (2005)	Understood the principles of spatial implications in creative organizations	Descriptive (Case study)	—	Two innovation labs (two organizations; Germany & Scandinavia)	Convergent & divergent thinking in the creative process (Wallas)
Pittaway et al. (2020)	Identified the characteristics of spaces for entrepreneurship in universities	Descriptive (Case study)	Four program-director interviews	Walkthroughs (one university) & analysis of 57 entrepreneurship spaces (U.S.)	Entrepreneurship from individual creativity & social interaction
Schmidt and Brinks (2017)	Explored new spatial settings for innovation and creativity as places for communities	Descriptive (Qualitative)	Five lab expert interviews	53 creative labs (Germany)	Communities as valuable resources for innovation
Lee (2016)	Investigated the characteristics of the physical work environment in innovative startup companies	Descriptive (Qualitative)	26 workplace-designer & manager interviews	22 innovative startup companies (U.S.)	Employees' creative ideas & competitiveness for organizational innovation
Lewis and Moultrie (2005)	Investigated the structural/ infrastructural content and	Explanatory (Case study)		Three innovative labs (U. K.)	

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Appendix C (*continued*)

Source	Objective	Research design	Participants	Physical setting	Creativity
	the benefits of innovative labs		14 managerial & technical staff interviews		Individual creative behaviors for innovative performance
Focus 3. Exploring influences of specific spatial attributes on creativity					
Soares et al. (2020)	Explored the spatial aspects of creativity on university campuses	Descriptive (Case study)	—	Public spaces (one university; The Netherlands)	Creative encounters & interactive behaviors
Wanqing et al. (2020)	Proposed a model of creativity in common spaces of universities	Descriptive (Grounded theory)	20 faculty and graduate students for in-depth interviews	Public spaces (one university; China)	Creative behaviors & feelings of efficiency
Storvang and Nguyen (2020)	Investigated how workspace affects creativity and interactions	Descriptive (Case study)	—	Three cases: a new university campus, a center for performing arts, and a private manufacturing company (Denmark)	Changes and interactions for organizational creativity
Chi et al. (2021)	Explored how daily positive and negative activating moods influence changes in daily creativity at work	Descriptive (Qualitative)	70 creative-worker daily journals (20 different companies)	20 offices (Taiwan)	Creativity-related processes or behaviors
Sicotte et al. (2019)	Explored the relationship between work environment and team creativity and effectiveness	Descriptive (Case study)	40 interviews & 645 surveys (10 new product development teams)	Renovated offices (one hi-tech organization; Canada)	Team creativity
Kallio et al. (2015)	Explored the physical environment and organizational creative culture	Descriptive (Case study)	15 employee interviews & 185 employee survey	Relocated offices (one newspaper organization; Finland)	Organizational culture for new ideas and outcomes
Hoff and Oberg (2015)	Explored the role of the physical environment for creative employees	Descriptive (Qualitative)	13 digital-artist interviews (six different companies)	Workplaces (six video games or movie businesses; Sweden, England, Germany, Norway, & U.S.)	Nature of creative tasks
Sailer (2011)	Identified the impact of spatial changes on interaction patterns at work to enhance creativity	Descriptive (Case study)	22 managing directors for semi-structured interviews and 155 employee surveys	Relocated offices (one large media organization; U.K.)	Interaction patterns & creative work at each phase (Wallas)
Vithayatha-wornwong et al. (2003)	Examined the role of the physical environment in supporting organizational creativity	Descriptive (Case study)	130 employee surveys from 4 organizations	Workplaces (four recognized organizations with innovation; U.S.)	Creative organizational climate questionnaire
Wagner and Growe (2020)	Understood how processes and the quality of physical spaces support creative knowledge generation	Descriptive (Qualitative)	Six participant/ facilitator interviews (design thinking workshop)	Workplaces (One global coworking company; Germany)	Creative knowledge generation
Bouncken and Aslam (2019)	Explored the relationship between spatial co-location and the knowledge-sharing processes	Descriptive (Grounded theory)	26 freelancer/ entrepreneur/ consultant interviews	Workplaces (various coworking offices; Germany)	Knowledge sharing & collaboration
Ceylan et al. (2008)	Explored the influential physical elements of office environments on creative potential	Descriptive (Mixed)	60 manager surveys (a large-size manufacturing facility; Turkey)	Workplaces (25 different office environments; international architecture magazines)	Potential to solve a complex problem; Physical environments (McCoy & Evans, 2002)
Dul and Ceylan (2011)	Explored the effects of socio-organizational and physical elements of creative work environments on employee creativity	Descriptive (Quantitative)	409 employee surveys	Workplaces (One pest control service company; The Netherlands)	CDQS for employee creativity
Martens (2011)	Explored how the physical environment could support or inhibit creative behaviors at work	Descriptive (Qualitative)	Ten creative professional interviews	Offices (U.K. & The Netherlands)	Creative process (Wallas); Communication; Flow; Motivation & expertise (Amabile, 1998)
Lukersmith and Burgess-Limerick (2013)	Explored the perception of work environment factors that can facilitate	Descriptive (Quantitative)	361 health-professional surveys	Healthcare facilities (Australia)	CDQS

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Appendix C (*continued*)

Source	Objective	Research design	Participants	Physical setting	Creativity
	creativity for health professionals				
Dul and Ceylan (2014)	Investigated the relationship between creative work environments and organizational performance in product innovation	Descriptive (Quantitative)	103 HR managers, senior managers	Workplaces (103 automotive, textile, service, food, and other industries; Turkey)	CDQS New product success

TTCT: The Torrance Tests of Creative Thinking; AUT: The Alternative Uses Task; RAT: Remote Associates Test; CDQS: Creativity Development Quick Scan.

creativity and physical environments. From a macro perspective, results showed that studies on creative environments have emerged in the past two decades, with a focus on creative cultures in organizations and the implementation of creative abilities (i.e., innovation). Management and organizational facilities were the main focus of two-thirds of the research articles, but the approach to creativity has recently become more interdisciplinary, incorporating psychology and education. However, research on the physical context of creativity still needs to be improved, with many studies conducted on single cohorts or facilities within a single country, particularly when experimenting with creative abilities or exploring user perceptions. The lack of comprehensive frameworks for understanding the concepts of creativity supported by the physical environment highlights the need for a more holistic understanding of the causal effects of the physical creative context.

This scoping review contributes to the existing literature by examining the relationships between key concepts of creativity affected by the physical context. Through the review of 33 research articles, this study found that creativity can be viewed through three concepts: creative thinking abilities, the potential for creative work performance, and culture/climates that stimulate creativity. Based on the widely accepted definition of creativity as the generation of novel and valuable ideas, the reviewed articles established unique perspectives of creativity in both domain-specific and general situations at the individual and group levels. Moreover, the significant physical environments discussed in this review were found to impact creative behavior as cognitive and perceptual stimulation, aligning with the previous statement by Amabile (1996) and Haner (2005). While only nine studies experimentally validated the effect of physical attributes on creativity, the other 24 confirmed the psychosocial and functional impact of physical surroundings on creativity. This section highlights the findings of this scoping review and suggests future research directions.

The most studied concept of creativity involves an organizational culture that promotes interactions and motivates creative activities at work. These studies view creativity as a social process influenced by environmental cues (Amabile & Pillemer, 2012; Sailer, 2011), which ultimately rely on individual or group skills to generate and support creative ideas. However, only two studies examined how teams perform specific tasks concerning their physical surroundings due to team dynamics, while others focused on employee perceptions of the cultural aspects. Social factors such as freedom and motivation have been shown to enhance organizational creativity (Amabile, 2018; Vithayanthawornwong et al., 2003). Studies have also identified significant physical attributes that support individual creativity. Universal skills, such as divergent and convergent thinking and idea generation, were identified as the components of creative performance at work, along with professional knowledge and motivational factors (Amabile, 1996; Amabile & Pratt, 2016). According to the dynamic componential model of creativity (Amabile & Pratt, 2016), individual effort can be synergistic with external influences. However, the direct connection between physical space design and creative thinking skills or performance is not yet well-established in the literature. Considering the link between individual and organizational creativity, it is worth noting that one can transfer the impact of environmental support to the long term.

Among the 15 significant physical attributes (i.e., light, furniture, visual stimulation, indoor plants, window, privacy, proximity, air quality, sounds, odors, volume, technical support, spatial variety, sense of control, and personal or cultural reflection) and seven spatial types (i.e., open spaces, social spaces, exploration zone, recharging spaces, mixed-use spaces, balanced layouts, and production labs), the "visual stimulation" category and the "social spaces" category appeared the most frequently linked to a wide range of creativity concepts. For example, the presence of visual details in the interior environment (e.g., colors, materials, high/low complexity of the elements, unconventional shapes or forms of interior elements) was shown to impact higher divergent or convergent thinking (Wu et al., 2021), inspire creative idea generation (Wagner & Growe, 2020), and support creative performance (De Paoli et al., 2019; Hoff & Oberg, 2015; McCoy & Evans, 2002). The second most frequently referenced physical attributes were "light" and "volume," which are more measurable variables (e.g., the brightness of lighting, ceiling heights, etc.) compared to less mentioned categories, such as "odors."

The study used various methods to experimentally and perceptually identify the visible and measurable elements that may play a potential role in creative environments. This review acknowledged that the efforts of McCoy and Evans (2002) to convert interior design elements into measurable variables for creative performance which inspired many scholars to seek direct effects of the physical environment. On the other hand, the Creative Development Quick Scan (Dul & Ceylan, 2011) offers a framework that is more perceptual in nature, suggesting that factors such as odors, plants, comfortable furniture, and air quality can contribute to a creative work environment. Three studies utilized this checklist to explore the overall physical work environment and its impact on employee creativity across industries (Dul & Ceylan, 2011, 2014; Lukersmith & Burgess-Limerick, 2013). Such accommodations can evoke beneficial multi-sensory dimensions that are often underexamined. Auditory, olfactory, and tactile input into environments can also be

Appendix D
Codes of creativity concepts.

Themes	Creative outcomes			Involved conceptualization (excerpts)
Creative thinking	Divergent thinking		• Higher resistance to closure • Higher fluency and flexibility score • Higher originality score • Higher fluency score • Higher novelty	• "Creativity could be manifested through different skills such as flexibility, fluency, originality, memory, risk-taking and problem solving" (Lan et al., 2021) • "Creativity is a changeable state" (Wu et al., 2021) • "We define creativity … as the generation of novel ideas" (Zhou et al., 2020)
	Convergent thinking		• Higher convergent thinking score	
	Creative idea generation		• Inspirational support for creative idea generation • More fluent ideas • Creative idea generation • Implementation of ideas • Articulation of ideas	• "flow of ideas" (Oksanen & Stahle, 2013)
Potential for creative performance	Creative performance (individual)		• Highly rated for the creative potential to work creatively, importantly considered for creative performance • Higher creative task score, inspirational for creative performance	• "The creative individual or group experiences a creative process that develops into a creative outcome" (Hoff & Oberg, 2015) • "group members build collaboratively on one another's ideas in the course of a work task" (Knight & Baer, 2014)
	Team creative performance		• Higher team creative performance • Team creativity	
Stimulating climates	Social gathering and informal knowledge exchange for creative culture	Interactive culture	• Interactive and creative work culture • Dynamism to promote creativity at work • Creative culture stimulates interactions	• "creativity occurs in the interaction between the individuals and a combination of a number of societal, cultural and organizational factors as well as between the individual, group and organizational levels" (De Paoli et al., 2019) • "openness, flexibility, and collaboration … foster and organize creativity and innovation-oriented activities" (Schmidt & Brinks, 2017) • "The creative process refers to the sequence of thoughts and actions that leads to novel, adaptive productions" (Martens, 2011) • "browsing and brainstorming can be considered to require divergent thinking … analyzing and deciding are very much single-focus activities requiring convergent behavior…" (Haner, 2005)
		Social interaction/ knowledge sharing	• Social gathering and informal knowledge exchange • Creativity through interactions • Psychological support to decrease social barriers • Potential for creative encounters • Social interaction of individual creativity • Innovation as a social process • Knowledge sharing and collaboration	
	Encouraging various activities for different phases of the creative process	Motivate various creative activities	• Motivation in enhancing divergent and convergent creative activities • Supporting different phases of creative processes • Displaying diverse creative behaviors	
		Encouraging culture	• Creative organizational culture to support creative behaviors flourish	

considered inspirational factors associated with creativity.

The overall concepts of creativity are closely involved in various social spaces, including informal interactive areas (e.g.,Chi et al., 2021; Kallio et al., 2015; Martens, 2011) and group working and learning spaces (e.g., Bouncken & Aslam, 2019; Haner, 2005). Articles that addressed the roles of social gathering spaces primarily emphasized creative climates that support knowledge sharing through social interaction and various actions related to the creative process. Studies also recognized the importance of social spaces to creative idea generation when collaborative activities are involved (Lee, 2016; Magadley & Birdi, 2009; Oksanen & Stahle, 2013). Especially, occupants' perceptions and observations widely validated the benefits of having well-designed social spaces. However, only one study using space syntax examined the potential for creative encounters through shared circulations in public spaces (Soares et al., 2020). Other studies considered the indirect effect of the physical environment, based on the belief in intervening variables (e.g., communication, social interaction, or knowledge exchange) for creativity. Additionally, exploration zones constitute incubation spaces where individuals or groups can concentrate on creative idea generation or work tasks (e.g., Hoff & Oberg, 2015; Pittaway et al., 2020). However, sources suggest these spatial types might enhance individual or organizational creativity. Developing a favorable environment can enhance creativity, but there is a need for validated evidence to suggest impactful spaces to facilitate creativity. Observations in innovative spaces can still identify the beneficial features of environments in detail. For example, the physical attributes identified in this study can be applied to creative exploration zones where unusual materials for creative idea generation are available (Wagner & Growe, 2020).

In addition, this scoping review recognized that most studies defined creativity as producing novel and valuable ideas. In addition, researchers respected creativity's subjective and social aspects and expanded or transformed this definition to apply their outcomes to the research context. However, some studies did not clearly define creativity when exploring the indirect effects of the environments (e.g., interactive culture) rather than the direct influence of specific physical environment features on creative abilities or performance. Furthermore, studies based on the Wallas model of the creative process did not provide clear mechanisms for how physical space influences creative behaviors. It is important to clarify the direct causal connections between physical space and creative behaviors to develop a more comprehensive architectural framework for the stages of the creative processes.

One limitation of this study is that this review included positive relationships between physical environments and creativity from the literature. While screening, we excluded two studies with null effects of the environment on creativity to identify the supportive elements for enhancing creativity. Consequently, this study may have missed opportunities to collect contrasting factors on creativity. Another limitation involves the functional context of the physical environment. The current study only focused on adult creativity in various settings without restrictions to embrace possible physical elements for creative environments. Future research could provide more practical implications with defined spaces.

Future studies may expand the relationships among physical environments, creative thinking abilities (i.e., divergent thinking or idea generation), and teams' creative potential during various processing phases. This study emphasized the transferrable benefits of individual creative capacity, recommending that future studies focus on the environmental investment in individual creative processes at all distinctive stages. When studies identify various forms of impact on creativity, the physical environments narrow from multiple perspectives to more manageable single variables. Additional empirical research on spatial experiences with multi-sensory variables is needed. Since creativity can be contextualized in various ways, the use of cross-cultural research participants and settings will also advance the literature on the physical environment's role in creativity.

4.1. Proposed agenda

The future research plan could include the following issues.

- Examine the direct effect of the 15 significant physical attributes within the seven types of spaces and creativity. Further experimentation is needed to expand the evidence on better supporting various behaviors linked to creative processes.
- Explore the environmental impact on team creative performance. Empirical relationships will enable validation between actual team creative performance and physical design.
- Identify how qualities of auditory, olfactory, and tactile elements in the environment can influence creativity. The research needs to determine the multi-sensory elements in which intensity levels stimulate creative behaviors.
- Assess the differential perception of environmental attributes associated with creativity among individuals across various occupations and demographics (e.g., different job types or age groups) and within certain functional contexts.

In addition to the above, spatial design in the post-COVID-19 period may need to consider the active integration of technology for working and learning environments. "Technical support" is included in the 15 physical attributes of this study, comprising both hardware and software. Many creative activities have used technology within or beyond the physical environment.

5. Conclusions

Creativity and innovation are currently attractive topics, and interest in the creative press includes the role of the physical environment. This scoping review examined the positive relationship between physical environments and creativity, as reflected in 33 empirical studies. Three concepts of creativity were identified: creative thinking abilities, potential for creative performance, and creative climates, as well as 15 significant physical attributes and seven space types. Some studies provided experimental evidence of the effects of interior design elements on creativity, while perceptually stimulating environments could enhance creativity through

physical contexts. Social spaces were frequently found to be influential on creativity, and it was noted that many studies treated creativity as an overall innovative culture of organizations, encompassing individual abilities and actions. It was concluded that appropriate environmental settings can support individual incubation and exploration and inspire communities to perform creatively at optimal levels. This study also calls for further research investigating the role of environmental attributes in specific contexts employing heterogeneous samples.

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CRediT authorship contribution statement

Jae Hwa Lee: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Supervision, Writing – original draft, Writing – review & editing. **Soyeon Lee:** Investigation, Data curation, Software, Visualization, Project administration, Funding acquisition, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

None.

Data availability

Data will be made available on request.

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Appendix

Appendix A, Appendix B, Appendix C, Appendix D

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