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Review Article

A Systematic Literature Review of Design Considerations, Challenges and Guidelines in Primary School Physical Learning Space Design

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ABSTRACT

Many countries are keen to enhance existing learning spaces beyond the status quo, as non-traditional learning spaces can be leveraged to cultivate talent and ability in the 21st century. Recently, many primary schools have begun to practice planning and constructing non-traditional learning. This review highlights the available evidence on the considerations, challenges, and existing learning space design guidelines based on primary-school research conducted from 2000 to January 2024. The Web of Science (WoS) and Scopus databases are intensively searched for research conducted in primary school settings in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The finding shows optimism regarding non-traditional learning spaces fostering more flexible, innovative, and open learning environments that support and assist student-centred pedagogical approaches, and it summarises the three results from the seven aspects. The primary considerations are physical space and pedagogical organisational design, challenges from users and designers and current research and guidelines for users and designers. Based on the three study results, this research proposes suggestions for physical learning spaces. There is an urgent need to design guidelines to promote primary school learning efficiency and create an environment that students and teachers like.

Keywords: Educational building, learning spaces, physical design, primary schools, systematic literature review (SLR)

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INTRODUCTION

Job disruptions, the need for new skills, and growing socio-economic polarisation exert increased pressure on primary school systems to educate future workers and global citizens (World Economic Forum, 2020). Global educational approaches

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have undergone a substantial revolution in the past two decades to support a student-centred approach to teaching and learning (T&L; Li et al., 2005). Many countries are keen to enhance existing learning spaces beyond the status quo, where non-traditional learning spaces can be leveraged to cultivate abilities and talents in the 21st century, which include cooperation, empathy, social awareness and global citizenship to foster quality education (World Economic Forum, 2020). Following the COVID-19 epidemic, students need to acquire skills like resilience, adaptability, and critical thinking in addition to academic knowledge (Abdollahi et al., 2020), and the teacher has more options for digital technology (Brown et al., 2021).

Learning space design has always attracted much attention and is influenced by the teaching mode and curriculum. Physical learning spaces are the most crucial modern infrastructural necessity for 21st-century education (Uduku, 2015). Physical design is crucial in classroom management (Gremmen et al., 2016) and in promoting the transformation of the teaching and learning model (Szpytma & Szpytma, 2022). Cleveland and Fisher (2014) found that physical learning space design significantly impacts students' academic performance. Schools have begun redesigning classrooms to better utilise the physical environment (Attai et al., 2021) to create adaptable and frequently modifiable learning settings (Gremmen et al., 2016). Comfortable, safe, and flexible learning spaces are more conducive to stimulating students' learning interests and improving learning efficiency (Cardellino & Woolner, 2019; Cleveland & Fisher, 2014; Kariippanon et al., 2017; Vijapur et al., 2021).

Despite these obstacles, the early 21st century is marked by the return of innovative learning spaces (Cardellino & Woolner, 2019). The concepts of "mobile," "agile," and "flexible" learning environments from the twenty-first century, along with conscious pedagogical innovations, are what propel innovative learning spaces (Cleveland & Fisher, 2014). However, these environments can also be difficult for teachers and students as they become used to the new learning and working settings. These difficulties include loudness, visual distractions, and collaborative teaching methods, which can be difficult to implement (Mulcahy & Morrison, 2017). The lack of guidelines also makes designing and building learning spaces a rather open question for those involved (Rönnlund et al., 2021).

There are only two review articles (Jagust et al., 2018; Vijapur et al., 2021) related to the topic of "Primary School Physical Learning Space Design" in the Web of Science (WoS). Vijapur et al. (2021) mainly focused on the interior design and IEQ of non-traditional learning spaces and found a lack of reporting on the specific zoning, layout, and usage patterns. The literature indicates that problems concerning all the considerations of occupants within non-traditional learning spaces have hardly been addressed (Zhang et al., 2019). Jagust et al. (2018) mainly presented the

technology-enhanced learning between learning in formal and informal contexts. The two reviews were limited to ten years: 2007–2016 (Jagust et al., 2018) and 2010–2020 (Vijapur et al., 2021), and there is a limitation to the challenges and guidelines of 21st-century learning space.

This paper aims to highlight the available evidence on the considerations, challenges, and existing learning space design guidelines based on primary-school research conducted from 2000 to 2022 to bridge this gap. The systematic literature review was performed to address the following research questions (RQs):

- **RQ1:** What are the main learning space design considerations that affect teaching and learning activities?
- **RQ2:** What are the primary school learning space design challenges?
- **RQ3:** What existing design guidelines optimise primary school learning spaces?

METHODOLOGY

The systematic literature review methodology was used in this study to provide a thorough overview of the relevant literature and synthesise the findings (Liu et al., 2022). Systematic literature review (SLR) follows certain processes to collect substantial data from various databases, which will be carefully evaluated and categorised either qualitatively or quantitatively (Ghadwan et al., 2022). This study uses the SLR procedure that Denyer and Tranfield (2006) and Dash and Thilagam used to standardise SLR and writing style (2022). This protocol is known as "The Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA)" (Moher et al., 2010). Figure 1 depicts an overview of the PRISMA statement-based search and selection procedure. Relevant literature was identified using the appropriate inclusion and exclusion criteria (Shaffril et al., 2020; Xiao & Watson, 2019).

Search Strategy

The main databases searched in this study were the Web of Science and Scopus databases, which are prominent scholarly research databases (Gusenbauer & Haddaway, 2020; Martín-Martín et al., 2018). Using an electronic database search, literature from peer-reviewed journals was identified from the reference lists of all relevant articles. Keywords were identified in both databases with full search strings using Boolean operators, phrase searching, and truncation capabilities (Table 1). Only studies that met every one of the following inclusion criteria elements were considered for inclusion:

1. Peer-reviewed journal article in English
2. Published between 2000 and January 2024
3. Empirical paper

Research that focused on virtual space and outdoor areas was not included because

it was outside the scope of this paper. The following keywords were searched in combination with two databases. The search results are shown in Table 1.

- [primary school OR elementary school] +
- [design]+
- [traditional classroom (OR) physical learning space (OR) active learning space (OR) flexible learning space (OR) innovation learning space]

Table 1
Search strings

Database	Search string	Results
Scopus	"Primary school" OR "elementary school" AND "design" AND "traditional classroom" OR "physical learning space" OR " active learning space" OR "flexible learning space" OR "innovation learning space"	756
Web of Science	TS = (primary school OR elementary school) AND TS = (design) AND TS = (traditional classroom OR physical learning space OR active learning space OR flexible learning space OR innovation learning space)	355

Source: Authors' work

According to the PRISMA flowchart summary (Figure 1), a preliminary database, which included 1111 articles, was produced by reviewing the keywords across two databases. The initial screening step involved scanning the abstracts and titles and removing duplicates. A total of 29 duplicates were removed, and 871 articles were excluded to eliminate non-relevant articles that focus on teaching and learning, such as online learning, flipped classrooms, and blended learning. In a second stage review of the remaining 211 articles, 113 were excluded as the full text was unavailable and only focused on technology and the physical activities of spaces. Of the remaining 98 articles, 65 were excluded as they were teaching and learning, not primary school, and not conducted in a physical learning space when the researcher read the articles. Thus, 33 articles that had high-quality appraisals were included in the review.

Quality Appraisal

Quality appraisal is essential for determining bias in systematic review studies. The authors evaluated the 24 qualitative articles using the Critical Appraisal Skills Programme (CASP) qualitative studies checklist, and eight quantitative articles used observational cohort and cross-sectional studies developed by the National Institute of Health (National Heart, Lung, and Blood Institute, 2021). CASP contains ten appraisal questions to assess the risk of bias in qualitative studies. The evaluation procedure was recorded in Microsoft Excel, employing indicators such

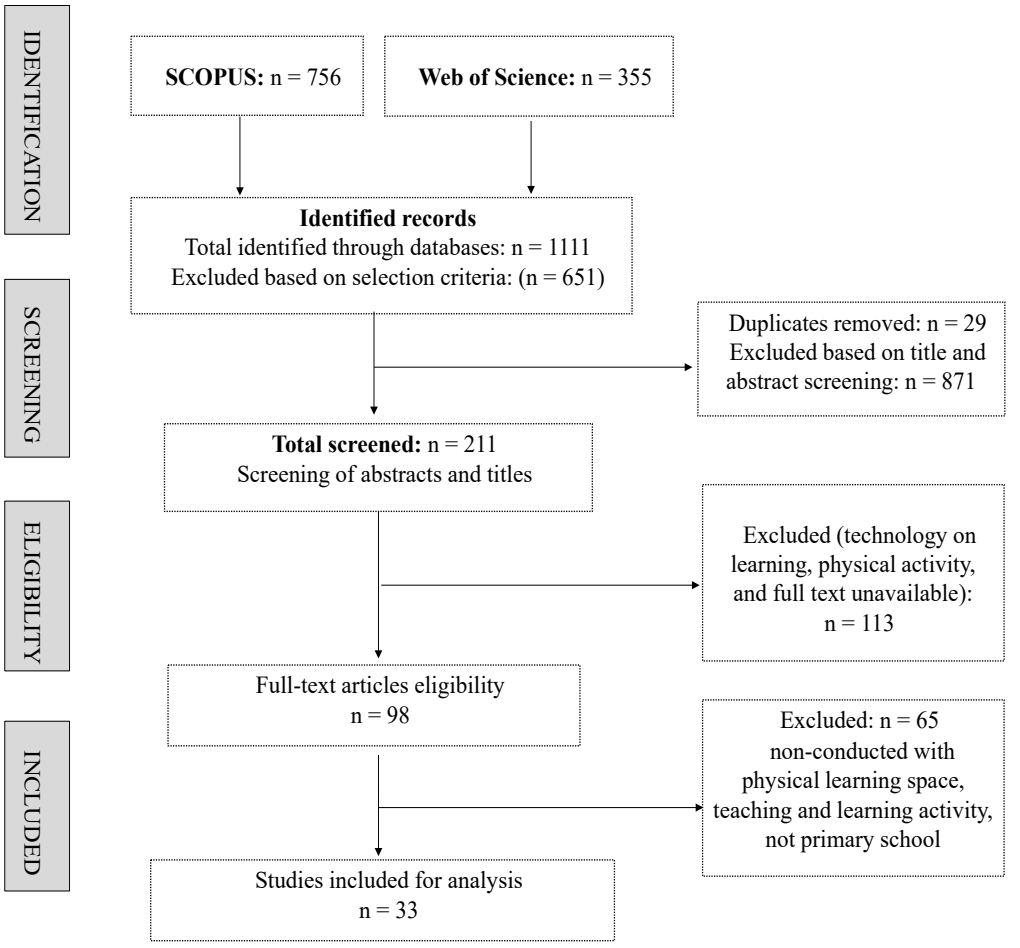

Figure 1. The PRISMA flow diagram summarising the study selection
Source: Authors' work

as Yes (Y), No (N), and Can't Tell (CT). The evaluation method revealed that the chosen studies were fair (scoring seven to nine out of 10 items). Observational Cohort and Cross-Sectional Studies consist of 14 items to which the evaluators would respond with a "yes," "no," or other ("CD: cannot determine", "NA: not applicable", or "NR: not reported",). As a result, the evaluation method showed that the chosen studies had a fair quality (scoring eight and 12 out of 14 items).

Data Analysis

The 34 articles were analysed using the qualitative thematic analysis method, which followed six steps (Braun & Clarke, 2006), as shown in Figure 2. As introduced by Zairul et al. (2023), it is imperative to verify the metadata of the chosen articles to ensure they fulfil the requirements and suit. We have double-checked the publication dates to ensure the articles are published during the evaluation period. A procedure was

followed to make sure that all relevant data was provided. The included studies' abstract, findings, discussion, and conclusion sections were examined carefully. Data that could address the RQs was collated and analysed thematically. The thematic analysis was conducted by grouping, condensing, and examining parallels and correlations to identify recurring themes. Three themes and seven subthemes were summarised from the 28 initial codes in this study. The authors' primary reason for creating these codes was the articles' heavy emphasis and repetition. It is common for the researcher to code the article abstract, introduction, results, discussion and conclusions, then to expand and summarise those codes into themes and subthemes. The themes, sub-themes and codes are shown in Table 2.

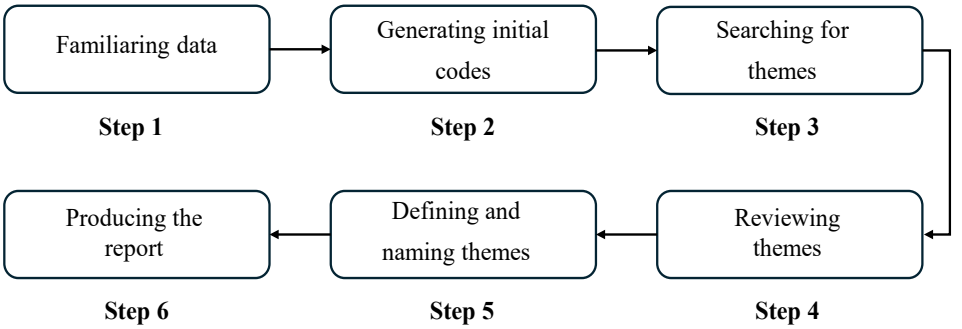

Figure 2. Six steps of thematic analysis

Source: Braun and Clarke (2006)

Table 2
Themes, subthemes and initial codes

Themes	Sub-themes	Initial codes
Physical space design and pedagogical organisation	Physical space design	Naturalness (visual -windows, door, nature; acoustic; temperature) Comfort Ownership Flexibility Complexity (colour) Child-friendly and learning needs Layout Furniture (desk, seat)
	Pedagogical organisation	Organisation (scheduling and curriculum) Staff culture Student milieu (motivation, social climate) Principals and senior leaders support

Table 2 *(Continue)*

Themes	Sub-themes	Initial codes
Users, designers and research challenges	Users challenge	Leader: Insufficient mechanisms Teacher: New forms of leadership and collaboration Greater empathy and appreciation Teacher educated decisions Students: Student skills and coping strategy
	Designer challenge	Combine design factors Formed decisions
	Research challenge	Small sample size Fewer theories Investigate many socio-material components, instructional strategies, ergonomic health concerns, and student and teacher control levels
Design guidelines for users and designers	User guidelines	User participant design process Professional learning mechanisms Pedagogy consistency
	Designer guidelines	Flexible classroom supplies Social interaction Students' desires and expectations

Source: Authors' work

RESULTS AND DISCUSSION

Each article was examined to determine the (1) research technique, (2) study purpose, (3) learning space (traditional or non-traditional), and (4) number of participants. Table 3 summarises the analysis findings. Among the 34 articles in the review, 17 focused on non-traditional learning spaces, innovative learning environments (ILEs), open learning spaces, and flexible learning environments. Five articles focused on traditional learning spaces, one focused on mixed learning spaces, and others did not mention space type. One article reported a comparative study of traditional and non-traditional spaces. Twenty-four studies used qualitative research methods, 8 used quantitative, and 2 reported mixed-method studies.

We categorised and assessed the papers. The original codes underwent multiple rounds of recoding, merging, and categorisation. Codes that were used infrequently and not related to the questions were removed. Three themes emerged in the end, as shown in Table 4: (1) physical space design and pedagogical organisation, (2) users, designers and research challenges, and (3) design guidelines for users and designers. Results outside the topics or the evaluated publications will be provided for explanatory purposes when necessary. Each theme comprises two or three sub-themes, which were further studied below (Figure 3).

Table 3
The analysis results

No.	Author	Country	Space	Participant	Method	Study purpose
1.	Niemi et al. (2022)	Finland	NT	N = 684 S (8–13 years)	Quantitative	Investigate students' opinions on flexible and open learning environments and the degree to which these views relate to student satisfaction with their education.
2.	Reinius et al. (2021)	Finland	NT	N = 17 S (second-grade)	Qualitative	Examine the activities that students and teachers engage in at 'deskless schools' (flexible physical classroom spaces)
3.	Campbell et al. (2013)	Australia	NT	N = 3 schools	Qualitative	Determine how non-traditional settings influence instructional practices and the challenges created for professional development.
4.	Saltmarsh et al. (2015)	Australia	NT	N = 3 schools	Qualitative	Determine the influence of teachers' ideas and methods of applying pedagogy theories on open-plan spaces.
5.	Starkey et al. (2021)	New Zealand	NT	N = 1 school	Qualitative	Investigate furniture usage in a flexible learning environment.
6.	Carvalho et al. (2020)	New Zealand	NT	N = 222 primary school teachers, 126 secondary school teachers, and 163 school leaders	Mixed method	Investigate the relationship between learning environments and academic courses and the influence of learning environments on primary school students' performance in mathematics and the arts.
7.	Cardellino and Woolner (2019)	UK	NT	N = One school	Qualitative	Analyse the relationships between teaching, learning, and space to support education changes.
8.	Reh et al. (2011)	Germany	NT	N = One school	Qualitative	Examine the relationship between educational practices, power, and space.

Table 3 *(Continue)*

No.	Author	Country	Space	Participant	Method	Study purpose
9.	Oliveras-Ortiz et al. (2021)	USA	NT	N = 35 S	Qualitative	Explore students' perceptions of the influence of learning environment design on student engagement.
10.	Baloğlu (2019)	Turkey	NT	N = 142 T from 15 primary schools	Qualitative	Explore the close relation of educational philosophies and methods with the built environment design that accommodates them.
11.	Rönnlund et al. (2021)	Sweden	T, NT	N = 20 principals, school managers, and architects	Qualitative	How stakeholders perceive social, pedagogical, and physical components of learning settings.
12.	Harouni (2013)	USA	T	N = 3 T and 3 S	Qualitative	Explore the recycled uniformity relationship between a creative public school teacher and the school settings
13.	Herman and Tondeur (2021)	Belgium	*	N = 9 T	Qualitative	Explore the space-human activity relationship.
14.	Barrett et al. (2015)	UK	*	N = 3766 S	Quantitative	Determine how physical classroom elements affect students' academic development.
15.	Wang and Wang (2020)	China	T	N = 17 T	Qualitative	Determine teachers' willingness to engage in cooperative learning and the challenges of cooperative learning in space.
16.	López-Chao et al. (2020)	Spain	T	N = 583 S	Quantitative	Investigate the relationship between learning environments and academic courses and the influence of learning environments on primary school students' performance in mathematics and the arts.
17.	Deppeler et al. (2022)	Australia	NT	N = 1 school (architect, principals, 4T, 98 S)	Qualitative	Examine how the architects and school administrators comprehended the risks, values, and educational goals that influenced the design of the new school building and gauge how the community views it.

Table 3 *(Continue)*

No.	Author	Country	Space	Participant	Method	Study purpose
18.	Mackey et al. (2018)	Australia	NT	N = 28 T and 16 school leaders from a total of 17 schools	Mixed method	Examine the experiences of principals and teachers in moving to a co-teaching environment, highlighting some of the new opportunities and difficulties that leaders have in helping teachers function well in these cooperative settings.
19.	Sigurdardottir and Hjartarson (2016)	Iceland	NT	N = 1 school	Qualitative	Expose the educational principles underlying a comparatively innovative school design and assess their performance in classroom settings.
20.	Bluteau et al. (2022)	France	NT	N = 107 S	Quantitative	Analyse how flexible seating affects elementary school children's mental and general well-being.
21.	Attai et al. (2021)	USA	*	N = 206 S from 10 classrooms	Qualitative	Explored the different effects of adaptable furniture in conjunction with professional development (PD) for teachers in primary schools.
22.	Tokarek et al. (2022)	USA	*	N = 99 S	Quantitative	Examine whether students use stand-biased desks during the school day affects their after-school sedentary and physical activity habits.
23.	Swartz et al. (2020)	USA	*	N = 97 S	Qualitative	Assess the effects of a stand-biased desk on fidgeting and attention.
24.	Wallace et al. (2022)	USA	*	N = 99 S	Quantitative	Stand-biased desks showed moderate improvements in cognition and no deleterious effects, suggesting that they may be a helpful classroom intervention for elementary school children. There were no significant effects on cognition or behavioural ratings from the standing-biased desk intervention.
25.	Yao et al. (2024)	China	T	N = 40 S	Quantitative	Investigate the influence of electronic screen viewing distance on the visual perception comfort of students.
26.	To and Grierson (2019)	Scotland	*	N = 3 schools	Qualitative	Measure the natural experience of children within three primary school Spaces at different locations in Glasgow, Scotland.

Table 3 *(Continue)*

No	Author	Country	Space	Participant	Method	Study purpose
27.	Szpytma and Szpytma (2022)	Poland	T	N = 1 school	Qualitative	Explore Elementary school buildings in Poland, tracing their evolution and asking whether their problems are universally applicable.
28.	Nyabando and Evanshen (2022)	USA	NT	N = 16 S from 4 classrooms and 3 distracts	Qualitative	Examine how second-grade students view the physical learning environment in their classrooms.
29.	Mokhtarmanesh and Ghomeishi (2019)	Iran	*	N = 1 female elementary schools	Qualitative	Investigate the influence of the environment on users' decisions on school preference.
30.	S. Lee (2019)	Korea	*	N = School space innovation projects	Qualitative	Examine numerous recent initiatives to reorganise classrooms to identify their concrete features.
31.	Whitehouse (2009)	USA	NT	N = 1 school	Qualitative	Test the current iterations of transformational school design.
32.	Dolan et al. (2006)	USA	*	N = 1 school	Qualitative	Recognise as essential to a student's comfort as well as the particular tactics employed to preserve and improve the environment, a feeling of place, and a sense of neighbourhood.
33.	Killeen et al. (2003)	USA	*	N = 77 S	Quantitative	Examine whether children's ownership of their educational experience would increase if the artwork were permanently displayed in a school and integrated into the building's architecture.

Note. * = not mentioned; In space line: "NT" means non-traditional space; "T" means traditional space; In participant line: "S" means students; "T" means teacher.

Table 4
The author and theme originated

	Author	Physical space design and pedagogical organisation		Users, designers and research challenges			Design guidelines for user and designer	
		Physical space design	Pedagogical organisation	Users' challenges	Designers' challenges	Research challenges	User' Guideline	Designer Guideline
1.	Niemi et al. (2022)	-	-	-	-	/	-	/
2.	Reinius et al. (2021)	-	-	/	-	/	-	-
3.	Campbell et al. (2013)	-	/	/	-	-	/	-
4.	Saltmarsh et al. (2015)	/	-	-	-	/	-	-
5.	Starkey et al. (2021)	-	-	/	-	/	-	-
6.	Carvalho et al. (2020)	-	-	/	-	/	-	-
7.	Cardellino and Woolner (2019)	/	/	-	-	-	/	-
8.	Reh et al. (2011)	-	-	/	-	-	-	-
9.	Oliveras-Ortiz et al. (2021)	-	/	-	-	-	-	-
10.	Baloğlu (2019)	/	-	-	-	-	-	-
11.	Rönnlund et al. (2021)	-	-	-	-	/	/	-
12.	Harouni (2013)	-	-	-	-	/	-	-
13.	Herman and Tondeur (2021)	/	-	-	-	-	-	-
14.	Barrett et al. (2015)	/	-	-	/	-	-	/
15.	Wang and Wang (2020)	-	/	/	-	-	-	-
16.	López-Chao et al. (2020)	-	-	-	-	-	-	/

Table 4 *(Continue)*

	Author	Physical space design and pedagogical organisation		Users, designers and research challenges			Design guidelines for user and designer	
		Physical space design	Pedagogical organisation	Users' challenges	Designers' challenge	Research challenges	User' Guideline	Designer Guideline
17.	Deppeler et al. (2022)	-	-	-	/	-	-	-
18.	Mackey et al. (2018)	-	/	/	-	-	-	-
19.	Sigurdardottir and Hjartarson (2016)	/	-	-	-	-	-	-
20.	Bluteau et al. (2022)	/	-	/	-	-	-	-
21.	Attai et al. (2021)	/	-	-	-	-	-	-
22.	Tokarek et al. (2022)	/	-	-	-	-	-	-
23.	Swartz et al. (2020)	/	-	-	-	-	-	-
24.	Wallace et al. (2022)	/	-	-	-	-	-	-
25.	Yao et al. (2024)	/	-	-	-	-	-	-
26.	To and Grierson (2019)	/	-	-	-	-	-	-
27.	Szpytma and Szpytma (2022)	-	-	-	-	-	-	/
28.	Nyabando and Evanshen (2022)	-	-	-	-	/	-	-
29.	Mokhtarmanesh and Ghomeishi (2019)	/	-	-	-	-	-	-
30.	S. Lee (2019)	/	-	-	-	-	-	-
31.	Whitehouse (2009)	-	-	-	-	-	/	-
32.	Dolan et al. (2006)	/	-	-	-	-	-	-
33.	Killeen et al. (2003)	/	-	-	-	-	-	-

Note. "- " = not mentioned; " / " = mentioned
Source: Authors' work

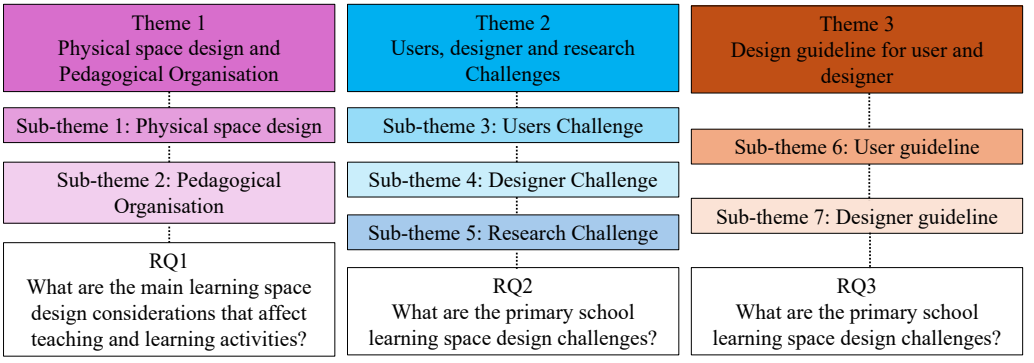

Figure 3. Overall network and how the themes answer the research question
Source: Authors' work

Physical Space Design and Pedagogical Organisation

To address RQ1, the 34 articles were inductively examined to produce categories of recurrent considerations, as shown in Table 5. The data were read and re-read to identify and categorise the derived factors into one theme: physical space design and pedagogical organisation.

Table 5
Design consideration

Design consideration		Citation
Physical space design	visual (windows, door, nature)	Barrett et al. (2015), To and Grierson (2019)
	acoustic	Sato and Bradley (2008)
	temperature	Barrett et al. (2015)
	furniture (desk, seat)	Attai et al. (2021), Bluteau et al. (2022), Swartz et al. (2020), Tokarek et al. (2022), Wallace et al. (2022)
	colour	Barrett et al. (2015), Mokhtarmanesh and Ghomeishi (2019)
	comfort	Dolan et al. (2006)
	ownership	Barrett et al. (2015), Herman and Tondeur (2021), Killeen et al. (2003)
	flexibility	Barrett et al. (2015), Bluteau et al. (2022), Gultekin and Ira (2022)
	complexity	Barrett et al. (2015)
	layout	Baloğlu (2019), Cardellino and Woolner (2019), K. S. Lee et al. (2019)
	child-friendly design and design for learning needs	Gultekin and Ira (2022)

Table 5 *(Continue)*

Design consideration		Citation
Pedagogical organisational design	Organisation (scheduling and curriculum)	Cardellino and Woolner (2019) Oliveras-Ortiz et al. (2021)
	Staff culture	
	Student milieu (motivation, social climate)	
	Student engagement	
	Principals and senior leaders support	Mackey et al. (2018)

Source: Authors' work

Physical Space Design

The transition to Education 4.0 shifted learning content and experiences, which imposed new demands on learning spaces. Educational methods must be modified to confer students with the knowledge and abilities to construct a more diverse, harmonious, and productive world (World Economic Forum, 2020). Furthermore, global educational policies emphasise teaching strategy modernisation and creating innovative learning environments that support 21st-century learning, such as the English and Welsh Building Schools for the Future initiative, the Canadian, Peruvian, and New Zealand ILE projects and the Australian Building the Education Revolution government programme. These new open-plan school designs were driven by the modern themes of mobile, agile, and flexible learning spaces (Dovey & Fisher, 2014).

The included articles demonstrated that physical learning spaces have become more open and flexible. Non-traditional physical learning spaces aided the improvement of cooperative and collaborative learning skills (Campbell et al., 2013), which align with the evolving demands of 21st-century education. Generally, modern learning spaces include technologically advanced areas without assigned student desks or teacher podiums. Larger spaces function as versatile working places given the presence of flexible furniture, different seating arrangements, removable dividers, and acoustic curtains or movable walls that encourage grouping (Campbell et al., 2013; Niemi et al., 2022; Saltmarsh et al., 2015). Students can occupy different positions in various locations, which enables more flexible physical activity and movement throughout the space. Flexible furniture and materials of non-traditional spaces require students to have self-control, problem-solving, self-reliance, cooperation, and soft skills such as working together to make the right decision (Bluteau et al., 2022). The non-traditional space is more flexible to adapt different teaching methods to align with the evolving demands of 21st-century education.

Expanding traditional classrooms provided students with more options on how

time, space, working groups, and working arrangements could be used while also conferring greater autonomy according to the pedagogical approach. Students in open and flexible learning environments frequently have more options for personalised learning, planning, decision-making, and taking ownership of supervising their work (Bøjer, 2019; Yeoman, 2018). Nevertheless, many students preferred classrooms with desks, single teachers, and walls to open school buildings. Additionally, several students complained that their schools were 'too modern' or 'too open'.

Many learning technologies, such as interactive whiteboards, personal learning environments, wireless networks, mobile devices, the internet, and high-quality digital learning resources, can be accessed from home and the workplace. Accordingly, such technologies are changing how students experience learning and what they hope to achieve (Joint Information Systems Committee, 2006). The literature review revealed that applying technology (mobile devices and their software) significantly improved students' learning interest and efficiency.

Digital technology is not only interactive but also provides teachers with more options than those they are accustomed to in the traditional physical learning environment (Brown et al., 2021). Digital technology also gains students' attention and interest, which enhances their learning motivation (Hoon & Shaharuddin, 2019). An examination of cognitive outcomes to determine whether children learned more with technology than by traditional classroom learning participation revealed that children achieved similar knowledge improvements with a self-directed learning method (iPhone game) and a guided method (traditional lesson; Furió et al., 2015). children can learn regardless of location and time without being present in a formal learning environment and do not require personal supervision.

Ahmad et al. (2017) reported that pupils demonstrated a modest understanding of the concept of technology, which suggested insufficient computers in the classroom. Osman et al. (2011) reported that no computers were available for students to use in the classroom. The classroom should feature technology, such as laptops and an internet connection, to facilitate obtaining T&L materials. Classroom technological equipment must, therefore, undergo periodic upgrading to satisfy pupils' needs.

Understanding how the created environment is used and perceived is crucial to physical space design. Woolner (2014) proposed a theory of user participation for effective design to enhance learning effectiveness, where user participation in school design is encouraged to ensure design alignment and comprehension among users. Recent studies confirmed that end users (students and teachers) should participate in designing and implementing new learning environments where students frequently prefer soft furnishings, vibrant colours, and technology-rich learning spaces in open learning environments and institutions (Niemi et al., 2022). Nonetheless, few designers considered users' wishes and

expectations (Niemi et al., 2022) and lacked a deeper understanding of classroom educational practices and how people, material, and space interact (Herman & Tondeur, 2021). Bruce Jilk successfully designed an innovative school in Iceland that is still being used as intended, where he included school officials and architects in the building factors of the organisation, pedagogy, and school space (Sigurdardottir & Hjartarson, 2016). Nevertheless, at the policy level, England's user participation design process was time-consuming, inefficient, and expensive (James, 2011). The design phase was considered time-consuming, but the users' long-term happiness disproved James's charges of inefficiency regarding the participatory design.

Pedagogical Organisation

A successful design is related to staff culture, student dynamics, and school organisation, which influence the infrastructure performance in a T&L environment (Gislason, 2010). Gislason's (2010) school climate model comprised four interconnected dimensions: organisation, staff culture, student milieu, and ecology. Gislason highlighted that these four elements need to interact with each other. This consistency is even more important when implementing non-traditional spaces involving new practices, organisation, and teaching. Organisation is vital to any learning environment (Cardellino & Woolner, 2019). Effective organisation and successful design are essential whenever non-traditional spaces are implemented (Gislason, 2010) and traditional spaces. Space design can foster student engagement (Oliveras-Ortiz et al., 2021). Time and investment are two essential aspects of effectively using non-traditional learning spaces in successfully transitioning teacher practice and pedagogies (Campbell et al., 2013). Thus, non-traditional learning spaces might be rapidly abandoned if teacher and administrator support is inadequate or the government does not allocate the necessary time, budget, and training.

Users, Designer and Research Challenges

The 34 articles were inductively examined to identify the key challenges to addressing RQ2. The data were analysed and summarised in terms of the themes of users, designers, and research challenges, as shown in Table 6.

Users' Challenges

Successful learning space design is significant in promoting new teaching methods (Niemi et al., 2022; Reinius et al., 2021; Saltmarsh et al., 2015; Starkey et al., 2021). The rapid evolution of non-traditional learning spaces has resulted in insufficient mechanisms for professional learning assistance (Campbell et al., 2013). New learning spaces require users to possess new teamwork skills (Campbell et al., 2013). Specifically, teachers must adopt new forms of leadership and collaboration among their colleagues and students. Teachers must be environmentally competent to make wise

Table 6
The summary of challenges

Theme	Category	Finding	Author
Users, designers and research challenge	User	**Leader:** Insufficient mechanisms **Teacher:** New forms of leadership and collaboration Greater empathy and appreciation Teacher educated decisions Co-teaching **Students:** Student skills and coping strategy	Bluteau et al. (2022), Campbell et al. (2013), Mackey et al. (2018), Starkey et al. (2021)
	Designer	Combine design factors Formed decisions	Barrett et al. (2015, 2016), Gislason (2010)
	Research	Small sample size Investigate many socio-material components, instructional strategies, ergonomic health concerns, and student and teacher control levels One-item indicator measurement error describes a trend toward innovative school design	Harouni, (2013), Niemi et al. (2022), Nyabando and Evanshen (2022), Rönnlund et al. (2021), Starkey et al. (2021)

decisions about utilising the classroom and help students make furniture use decisions (Carvalho et al., 2020). The teachers also need to establish expectations, plan the curriculum, arrange the area, and help the kids learn how to use it (Carvalho et al., 2020). Given that new learning spaces disrupt traditional teaching approaches, teachers are required to demonstrate greater empathy and appreciation for others practising in the space (Campbell et al., 2013). It also challenges how students can use, alter, and compromise their visibility and audibility in a school that has been "opened," as well as who, what, and how they can exhibit themselves (Reh et al., 2011). Overall, users should be able to make educated decisions about their environmental effects when they use the classroom and advise students on how to do the same (Starkey et al., 2021). Nonetheless, few studies examined the effects of new settings from the users' viewpoints and behaviours (Grannäs & Stavem, 2021).

Designer' Challenges

The learning space is a dynamic ecosystem that should be designed to meet educational practices and is considered a constantly shifting meshwork of interacting people, places, and things (Ingold, 2011). Policymakers and designers should understand classroom occurrences and users' practices.

López-Chao et al. (2020) stated that academic performance is directly related to room size, views, ventilation, and place attachment. Focus on space design enabled the identification and typifying of three design principles and seven environmental parameters (naturalness: light, temperature and air quality; individualisation: ownership and flexibility; simulation: complexity and colour), all of which form optimal learning spaces for students and improve pupils' academic performance (Barrett et al., 2015, 2016). According to Barrett et al. (2015), the naturalness design principle accounts for approximately 50% of the impact on learning, while the other two principles comprise approximately one-quarter. Nevertheless, several elements are designer issues and aid user adaptation of spaces to better support learning. Thus, addressing these factors in combination constitutes a design challenge (Barrett et al., 2015, 2016). The lack of educational building studies represents a substantial gap in education studies and indicates that designers and users rarely make informed decisions about school space design and use (Gislason, 2010).

Research Challenges

There are fewer theories in this field, which include only the school climate model (Gislason, 2010) and the SIN model (Barrett et al., 2015). More advanced theoretical and analytical techniques are also required to comprehend the essential components of learning environments, how designed environments shape interactions, and to develop instruments for assessing learning environments (Carvalho & Goodyear, 2014). There is also less sample size (Johler et al., 2022; Nyabando & Evanshen, 2022; Yao et al., 2024) and limited schools (Mackey et al., 2018). Research on the ongoing interactions of material, spatial, and human actors was scarce (Herman & Tondeur, 2021). Research has examined how changing school architecture affects users' viewpoints and behaviours (Reinius et al., 2021). Further study is required to examine furniture used in various modern classroom scenarios to create comprehensive literature about many facets of environmental competence. It entails looking into various socio-material components, pedagogical strategies, ergonomic health concerns, and student and teacher control levels (Carvalho et al., 2020).

More time and more research are needed to determine how innovative practices and educational changes will play out in the long run (Sigurdardottir & Hjartarson, 2016). Numerous theoretical debates centre on social structures, often known as "structurally moulded conditions," (Archer, 2003, p. 13) and how they affect people's ability to act in an agentive manner (Saltmarsh et al., 2015). It is difficult to investigate many socio-material components, instructional strategies, ergonomic health concerns, and student and teacher control levels (Starkey et al., 2021). Harouni (2013) found that educational environments cannot just describe socialising and control mechanisms. It needs to take into account people's attempts to fight back against the limits

within these systems. It is challenging when the stakeholders describe a trend towards innovative school design, and teachers' points have been ignored (Rönnlund et al., 2021).

Design Guideline for User and Designer

This paper summarised some guidelines to answer RQ3 (Table 7).

User' Guideline

The absence of design guidelines and standard definitions renders it challenging for teachers to manage spaces that are difficult to define (Dovey & Fisher, 2014). Consequently, the government should formulate policies to support users in managing and using their spaces. Policies supporting new learning space transformations and applications for users should be explored. The government and education department should review its regulations and promote the most recent teaching techniques, educational technologies, and equipment to users to establish efficient learning environments (Whitehouse, 2009).

Additional studies should examine stakeholders' influences on policy in relation to modern pedagogical approaches and the school environment (Rönnlund et al., 2021). It is also important to consider how teachers use learning spaces, including using user feedback (allowing teachers to collaborate with designers to create school buildings) from the design process to enhance the end design (Bøjer, 2019; Cardellino & Woolner, 2019).

Designer Guideline

School building quality affects academic performance (Barrett et al., 2015), as pupils share an apparent relationship with the environment (López-Chao et al., 2020). Sensory stimulation can both enhance and diminish a young child's learning process. Most primary school students are six to 12 and active, with unyielding curiosity and poor concentration. Therefore, the school design should be combined with students' age characteristics. The physical learning environment, furnishings, and flexible learning space resources should support and enable student-centric instructional practices.

Table 7
Design guidelines

Guideline
• Time and investment in change management should be considered for a successful shift of pedagogies and teacher practice to use agile and flexible learning spaces (Campbell et al., 2013).
• Professional learning mechanisms and support should be offered to meet this potential (Campbell et al., 2013).
• Students' desires and expectations for their schools and school days should be considered when redesigning a learning environment (Gultekin & Ira, 2022; Niemi et al., 2022).
• End users should be involved in the phases and processes of designing and implementing new learning environments (Gultekin & Ira, 2022; Niemi et al., 2022).

Table 7 *(Continue)*

	Guideline
	• A physical learning environment should be adaptable, open, interactive, aesthetically pleasing (or tailored to the kids' preferences), flexible, and integrated into the community. It should also be meant to serve as an educational tool (Gultekin & Ira, 2022).
	• Worldwide, more multidisciplinary studies in architecture, education, and psychology should focus on purposefully designed school environments (Szpytma & Szpytma, 2022).
	• The pedagogy should be aligned with the physical learning spaces (Gultekin & Ira, 2022).
	• There should be interesting focal points in classrooms and enough room for group work. As a result, classroom supplies (such as chairs, tables, and technology) need to be flexible (Gultekin & Ira, 2022).
	• Physical learning environments should be effective and extend learning beyond traditional classroom settings (Gultekin & Ira, 2022).
	• Classrooms should have focal points and physical layouts that facilitate group work. For this reason, the classroom furniture, technology, and presenting tools need to be flexible (Gultekin & Ira, 2022).
	• Social interaction should be encouraged in the design learning settings process (Gultekin & Ira, 2022).
Flexibility	Learning spaces should respond to diverse concurrent instructional activities.
	• Shared spaces between teachers, content areas, and communities can provide opportunities for ideas and socialisation.
	• There should be individualised, personal, or small-group inquiry-based learning spaces.
	• Open-plan informal learning spaces should be built from unused areas and provide personalised learning environments.
	• Learning place adaptability must be maximised.
	• Classrooms must allow differing group sizes and activities.
	Furniture
	• Must be flexible and sufficiently adaptable to be rearranged throughout the day.
	Wall
	• Wall system use should be flexible.
	• Walls should be movable to increase the effectiveness of multipurpose large spaces, such as gymnasiums and libraries.
Complexity	Learning spaces should respond to multidisciplinary teaching.
	• Interdisciplinary learning, thinking, and working should be used to identify issues and devise fresh creative methods to resolve them.
Ownership	• The main entry should be inclusive, exciting, welcoming, open, bright, safe, well-maintained, and demonstrate the school community values.
	• All school spaces should encourage learning, collaboration, and socialisation.
	• Space design should consider the requirements of disabled administrative staff, teachers, and pupils.

Table 7 *(Continue)*

	Guideline
Colour	The space should feature cold, soft colours. • Cold colours increase awareness levels and enhance concentration and memory. •A space should not contain more than three significant brightly coloured areas.
Light	• Daylighting (control of natural light entering the space) should be a priority. Glare and hot spots reduce learning effectiveness. • Controls, high-efficiency artificial lighting, and daylighting should be incorporated to maximise visual comfort.
Air quality	• The space must ensure superior indoor air quality by using natural ventilation. • Natural ventilation should improve engagement. The indoor space should be connected to the outdoors by providing easy access from classrooms to gardens and view windows in classrooms and other outdoor areas that can be utilised in the curriculum. Windows that face classrooms or other active areas (teacher prep areas or break rooms) should feature opening sashes.
Temperature	• The space must ensure thermal comfort. • Teachers can control the temperature of individual classrooms. • Appropriately sized heating, ventilation, and air conditioning (HVAC) systems should maintain comfortable humidity.

Source: Authors' work

CONCLUSION

This systematic review obtained the best available evidence globally to summarise the state of the art of physical learning spaces, wherein the considerations, challenges, design guidelines for spaces and pedagogical support were examined and analysed. The finding shows that the innovative learning space is easy to align with the evolving demands of 21st-century education, and technology can improve pedagogy and space transformation. From the review, there are two key findings:

First, compared to traditional learning spaces, new learning spaces are compatible with the most recent learning approaches and create a more flexible and engaging learning environment. The physical learning environment, furniture, and resources of flexible learning spaces can support and assist student-centred pedagogical approaches.

Second, researchers were concerned about the influence of technology on learning efficiency. Most research has demonstrated that technology can capture students' interest and attention as a learning tool. Recent studies focused on technology to promote T&L activity and suggested that learning space design should enhance technology use. However, there are insufficient computers in the classroom, and the level of student technology knowledge is low.

In the future, the government should support the new learning space by allocating the required time, money, and training. It also needs to provide the necessary professional learning assistance for users with sufficient mechanisms. Sufficient computers should be provided in the classroom, and student technology knowledge is low. Users are required to have new collaborative abilities and greater empathy and appreciation for others practising in the new space. The effects of new settings from the users' viewpoints and behaviours should be explored for the research.

This review did not identify a detailed guide for designing new learning spaces. Nevertheless, some considerations and directions were determined regarding the expected environment of schools, students, and teachers. Therefore, there is an urgent need to design detailed guidelines for promoting primary school learning efficiency and creating an environment that students and teachers like.

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