

Transforming Learning Spaces in the digitalization era: a bibliometric exploration of emerging trends

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Abstract

Learning Space is the physical and psychological place of acquiring knowledge, which has evolved significantly, influenced by technological advancements, pedagogical shifts, and changing student needs. The transformation of learning spaces is crucial for fulfilling the needs of the 21st generation learners and improving the learner's overall outcome. This study aims to explore the available literature on learning spaces to analyse the past, current and future trends of study themes, in learning spaces, through a bibliometric analysis approach. Vos viewer software is used to determine the author, countries, and publications, which have made the greatest contribution to learning spaces research, as well as the key themes and emerging trends of study. The findings of the study show that most of the learning space research is focused on the user experience in traditional and digitally equipped learning spaces, the impact of learning spaces on users' cognition, attitude, engagement, performance and well-being, and the design of innovative learning spaces. Still, there is a lack of research on the design and utilization of spaces to satisfy the needs of the 21st-century digital generation, for the well-being of the learner, and improvement of learning outcomes. The emerging theme of research is focused on the learner's mental, physical and social well-being. This study will help the researchers to understand the research gap in the field of learning space research.

KEYWORDS: Learning Spaces, Digitalization, Pedagogical Shifts, Well-Being, Bibliometric Analysis.

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1. Introduction

Research in learning spaces dates back to the 1990s, as retrieved from the Scopus database. There is a strong relationship between learning spaces, pedagogy, and technology (Sardinha et al., 2020). Still, compared to research on pedagogical approaches, the studies on learning spaces are very limited in educational research (Edgerton & Mckechnie, 2023; Zaid et al., 2021). There is an evident need to improve the learning spaces for adaptation to emerging educational needs (Almansour & Almoayad, 2024) and meet the global trend of

learning skills for the 21st century (Grannäs & Stavem, 2021). Educators are beginning to consider learning spaces as an additional resource to acquire desired learning outcomes in educational institutions (Attai et al., 2021), or 'learning organizations' focussed towards digital transformation (McGregor, 2004). It's a challenge to develop experiential learning, engagement and teamwork in the learning spaces to attain the goal of Education 4.0 (Munoz Cantero et al., 2016). If a country aspires to progress, it must achieve SDG-4 of quality education (OECD, 2017) and focus on Education 4.0. In the 21st century, the digital transformation of 'learning spaces' or 'built pedagogy' is leading towards smart learning (Wang et al., 2024) and innovation. The use of technologies supports an interactive and engaging learning experience, better learning outcomes and shifts in the learner's expectations of learning spaces (Aburas et al., 2014). These can contribute to the teaching-learning process (Zaid et al., 2021), student academic success (Choi et al., 2014), and the fulfilment of students' psychological needs (Ismail & Abdullah, 2018; Dhasmana et al., 2022).

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The first step towards effective learning is to understand the role of learning spaces. Various researchers have put forward different aspects of learning spaces to foster student learning (Young & Cleveland, 2022). Learning Spaces influence human behaviour and attitudes (Higgins et al., 2005), enhance learning outcomes (Owoseni et al., 2020), and increase satisfaction levels (Costa & Steffgen, 2020). Appropriately designed school spaces can play a significant role in the teaching-learning process (Szpytma & Szpytma, 2019) and the well-being of children (Chourasia et al., 2023). The Joint Information Systems Committee (JISC, 2006) has suggested that “Spaces themselves are agents for change and changing spaces will change practices”.

Bibliometric analysis is a method of evaluating development trends, to put forward the future direction of research in a particular field using statistical approaches (Xu & Yu, 2019). Diverse fields of study commonly use this method to map current and future study trends and identify research gaps. This research aims to determine the studies conducted on learning spaces and to analyse the current and future trends in studies of learning spaces through bibliometric research analysis and using the Scopus database. This study contributes to the knowledge of learning spaces, their impact on various aspects of learning and the learner, and the innovation in learning spaces. The study helps researchers throughout the world to know less explored themes. The study aims to determine the answers to four research questions:

RQ1: How much the research in learning spaces has gained importance in education and architecture research?

RQ2: Which authors, countries, and publications have made the maximum contribution to the learning spaces research?

RQ3: What are the main research themes and how they have evolved with time?

RQ4: What future research areas are prevalent in the educational and architecture research about learning spaces?

2. Research Methodology

2.1 Data Collection

The researcher has explored the Scopus database to collect data for this study. The Scopus database is quite popular for its peer-reviewed publications (Arora et al., 2022), and provides relevant data required to explore the existing literature on ‘Learning Spaces’. The required data for study had been acquired on July 4, 2024. Publications were collected through keywords search, either in the title, abstract or the author keywords. The keywords used for search engine are

“Conducive learning spaces” OR “Physical learning environment” OR “School built environment” OR “School spaces design”. The researcher has retrieved whole of the data published from 1996 to 2024, available on the study topic in the Scopus database. This data had helped the researcher to understand the growth of new fields of study towards achieving effective learning spaces, in the educational research.

The PRISMA or Preferred Reporting Items for Systematic Reviews and Meta-Analysis approach (Arora et al., 2022) had been utilized for data collection. This approach involves identification of the articles through keywords search, screening of the collected data (by limiting to ‘Final’ publication and ‘English’ language), checking the eligibility after proofreading of the articles, and including the remaining articles in the study. Table 1 represents published articles retrieved from the Scopus database. The PRISMA approach used in the study has been explained in Figure 1.

Table 1 - Publications retrieved for study.

Description	Results
Total documents	228
Article	157
Conference Paper	45
Book chapter	15
Review	9
Note	1
Erratum	1
Sources of documents	
Journals	156
Proceedings	38
Books	14
Others	8
Publication period	1996-2024
Authors	470
Author’s Keywords	590

2.2 Data Analysis

A large number of software are available to conduct bibliometric analysis. However, the researcher had chosen VOS viewer software to analyse the data, for its remarkable results. It is adopted mainly for network analysis and descriptive data analysis. The total publication count is 176, with 147 sources, 470 authors, 370 organisations, and 52 countries involved in the research on this theme. There was a total of 6900 cited references. The total number of keywords is 1201, the author keywords are 590 and the index keywords are 773. Data analysis is done by determining the publication count, citation count, co-citation analysis, and keyword co-occurrence.

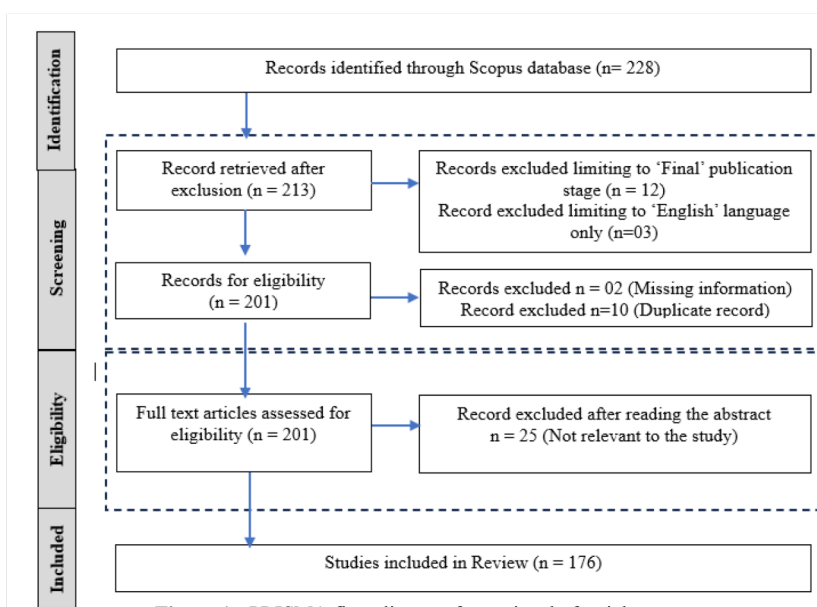


Figure 1 - PRISMA flow diagram for retrieval of articles.

3. Results of Analysis

3.1 Descriptive Data Analysis

Descriptive data analysis contains analyses of articles to determine the level of growth in publications, the productivity of authors, the most productive source, cited publication and the productive country.

Publication trends

The number of publications regarding learning spaces, in 1996 was as low as one publication. As the awareness grew the publication rose to 12 number of publications in the years 2018 and 2019. The COVID-19 pandemic made a remarkable increase in the studies from 16 publications in 2020 to 27 publications in 2021 (Figure 2). Later the publication score gets reduced to a certain extent to 17 articles in 2022 to 20 articles in 2023. The number of publications in 2024 is only 8, as the data analysed is till June 2024.

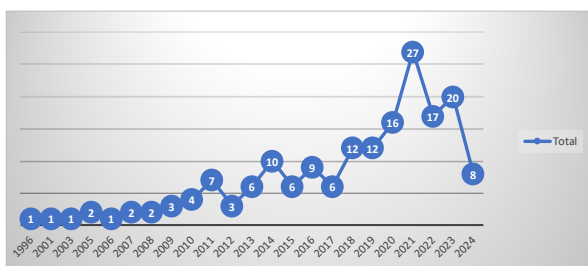


Figure 2 - Trend in publication.

3.2 Citation Analysis

Top Publications

Research on learning spaces has grown considerably since the past decade, evidenced by the increase in related publications. (Figure 2). Citations refer to the

value and acceptability of any article. The higher citations of a research article depict its credibility (Arora et al., 2022). Table 2 shows the most cited publications on the impact of learning spaces relate to cognition, social aspects, and student engagement. The publication with the maximum number of citations is by Choi H.H et al. (2014) with 225 citations. The second position is held by McCarthy’s (2010) publication with 187 citations and the third position by Mathews et al. (2011) with 125 citations.

Leading Universities

This section reviews the top five institutions contributing significantly to the field and has maximum citations worldwide. Table 3, signifies that although Tallinn University from Estonia has a maximum number of 11 citations, institutions from the Netherlands emphasise more on research in the field of learning spaces. Three universities from the Netherlands with 10 citations each, are among the five Universities with highly cited publications.

Most productive Authors

Table 4 represents the top ten productive authors based on the number of publications and their citations. The most productive author can be analysed by dividing the number of citations of an author by the number of publications. McCarthy J. emerged as the most productive author, with 187 citations and two publications. The second position is held by the Buliung R., Howard A., Macarthur C. and Rothman L., with 91 citations and two published documents. Cleveland B. with 141 citations and four publications grabbed the third position. Woolner P. hold the fourth position with 70 citations and two publications. Zandvliet D. B. stood in the fifth position.

Table 2 - Top ten Publications with maximum citations.

Rank	Author	Title	Year	Source	Citations
1	Choi H.-H., Van Merriënboer J.J.G., Paas F.	Effects of the Physical Environment on Cognitive Load and Learning: Towards a New Model of Cognitive Load	2014	Educational Psychology Review	225
2	McCarthy J.	Blended learning environments: Using social networking sites to enhance the first-year experience	2010	Australasian Journal of Educational Technology	187
3	Matthews K.E., Andrews V., Adams P.	Social learning spaces and student engagement	2011	Higher Education Research and Development	125
4	Young F., Cleveland B.	Affordances, Architecture and the Action Possibilities of Learning Environments: A Critical Review of the Literature and Future Directions	2014	Buildings	121
5	Steen-Utheim A.T., Foldnes N.	A qualitative investigation of student engagement in a flipped classroom	2018	Teaching in Higher Education	103
6	Cukurova M., Luckin R., Millán E., Mavrikis M.	The NISPI framework: Analysing collaborative problem-solving from students' physical interactions	2018	Computers and Education	75
7	Woolner P., Hall E.	Noise in schools: A holistic approach to the issue	2010	International Journal of Environmental Research and Public Health	68
8	Rothman L., Howard A., Buliung R., Macarthur C., Richmond S.A., Macpherson A.	School environments and social risk factors for child pedestrian-motor vehicle collisions: A case-control study	2017	Accident Analysis and Prevention	67
9	Getie A.S.	Factors affecting the attitudes of students towards learning English as a foreign language	2020	Cogent Education	65
10	Zandvliet D.B., Fraser B.J.	Physical and psychosocial environments associated with networked classrooms	2005	Learning Environments Research	63

Leading Sources of Publication

This research includes articles from 156 Journals, 38 conference proceedings, 14 books and 8 other publications. The top 3 publication sources with maximum citations and more than 3 publications are the Learning Environment Research, International Journal of Environmental Research and Public Health, and ACM International conference proceeding series (Table 5). Out of these three 'Learning Environments Research' tops the list with 12 publications and 312 citations.

Most productive country

Figure 3 represents the maximum number of publications by the top ten countries in the field of learning spaces. The United States tops the list with 30 articles, followed by Australia and the United Kingdom

with 19 and 16 articles respectively. India lies in the 6th position with 8 articles. Figure 4 represents the top 10 most productive countries according to citations. Australia is in the top position with 889 citations, the Netherlands has 305 citations and the United Kingdom has 284 citations. Canada with 264 citations is in the fourth position and the United States with 228 citations is in the fifth. India secures the 8th position with only 28 citations. The most productive countries are determined by dividing the citations by the number of publications. Australia is the most productive country in learning spaces research, followed by the Netherlands and the United Kingdom.

Table 3 - Top five Leading Universities.

Rank	Universities	Country	Documents	Citations
1	Tallinn University	Estonia	2	11
2	Delft University of Technology	Netherlands	2	10
3	Eindhoven University of Technology	Netherlands	2	10
4	NHL Stenden University	Netherlands	2	10
5	University of Otago	New Zealand	2	9

Table 4 - Author ranked based on Documents and Citations.

Authors ranked based on documents				Authors ranked based on citations			
Rank	Author	Documents	Citations	Rank	Author	Documents	Citations
1	Cleveland B.	4	141	1	Mccarthy J.	2	187
2	Helfenstein S.	3	52	2	Cleveland B.	4	141
3	Mäkelä T.	3	52	3	Buliung R.	2	91
4	Zandvliet D.B.	3	88	4	Howard A.	2	91
5	Almawaldi M.K.	2	1	5	Macarthur C.	2	91
6	Baars S.	2	10	6	Rothman L.	2	91
7	Barnes B.	2	37	7	Zandvliet D.B.	3	88
8	Brachtl S.	2	18	8	Woolner P.	2	70
9	Buliung R.	2	91	9	Helfenstein S.	3	52
10	Ciordas-Hertel G.-P.	2	8	10	Mäkelä T.	3	52
11	Cross D.	2	5	11	Barnes B.	2	37
12	Drachsler H.	2	8	12	Hao Q.	2	37
13	Francis J.	2	5	13	Jing M.	2	37
14	Gomes A.S.	2	2	14	Sigurdardóttir A.K.	2	31
15	Hao Q.	2	37	15	Brachtl S.	2	18

Table 5 - Leading Publication Source.

Rank	Source	Number of Articles Published	Citations
1	Learning Environments Research	12	312
2	International Journal of Environmental Research and Public Health	4	85
3	ACM International Conference Proceeding Series	3	33

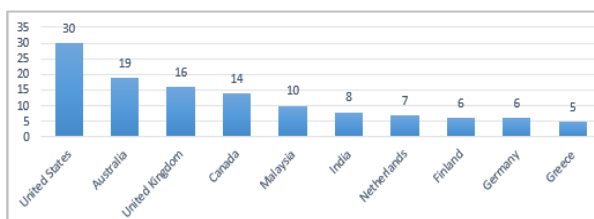


Figure 3 - Top ten productive countries according to publications.

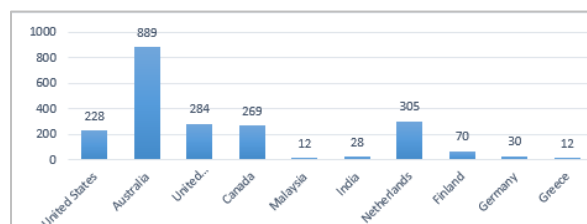


Figure 4 - Top ten productive countries according to citations.

3.3 Co-Citation Analysis

Cited references

Co-citation analysis of 6900 cited references has a total of 48 references, meeting a minimum of 3 citations of a cited reference. 48 items have been classified into four clusters with a minimum of 8 items in each cluster. Cluster 1 (red) has 19 items, Cluster 2 (green) has a total of 11 items, and Cluster 3 (blue) and 4 (yellow) have 9 items each (Figure 5). The research theme of Cluster 1 (red) addressed the innovative design of learning spaces, cluster 2 is based on the psychosocial environment, Cluster 3 studies the impact of learning spaces on learning and Cluster 4 relates to the evaluation of the school buildings.

Keyword Analysis

There are 553 author keywords out of which 25 meet the threshold of 3 occurrences minimum. Keywords with high occurrence are “learning spaces”, “learning environment”, “pedagogy”, “school buildings”, “higher education” and “built environment” (Table 6).

Figure 6 illustrates the emergence of various topics in educational learning spaces from 2013 to 2024. The network visualisation of all 1109 keywords has found 43 keywords with a minimum of three occurrences. 43 keywords have been classified into four clusters- red, blue, green and yellow. Cluster-1 (red) has 12 keywords related to school-built environment, Cluster-2 (green) has 11 keywords on technology integration, Cluster-3 (blue) has 10 keywords on well-being, and Cluster-4 (yellow) comprise 10 keywords on active learning spaces. The key themes identified from these clusters are school-built environment, technology integration, design for well-being, and active learning spaces.

4. Discussion and Findings

4.1 Importance

The publications depict that learning spaces have gained importance in education and architecture research. The research on learning spaces has shown tremendous growth, with the changing needs of the users, industry and the education system. The publication trend of learning spaces research shows an increase in articles, in 2011 and reached the heights in 2021. The increase in publications since 2020 is remarkable. The publications rose to a peak in the year 2021, after the Covid-19 pandemic, due to the raised attention of researchers towards online, and blended learning spaces. After 2021, the research is focused towards various other fields for the development of learning spaces to meet the needs of the 21st century.

4.2 Contribution

The most productive author if ranked based on documents is Cleveland, and the citations are McCarthy. The leading source of publication is ‘Learning Environment Research’ and the leading University is ‘Tallinn University’. Australia leads in the publication on learning spaces. Most of the research is limited to developed countries. There is a gap in research in underdeveloped countries. The most cited publication is by Choi H.H et al. (2014), followed by McCarthy (2010) and Mathews et al. (2011). Highly cited publications are related to the impact of learning spaces on cognition, social aspects, and student engagement.

4.3 Key Themes

Innovative school building design

In the design process of school building design, all three factors the teacher, the designer and the school management were involved but the learners were uninvolved (Bojer, 2020). So, buildings work against learner-centred pedagogies (Szpytma & Szpytma, 2019). Schools designed for educational purposes (Grannäs & Stavem, 2021), embeds flexibility, adaptability (Lefdal, 2023), and continuous learning (Maturana et al., 2021). Flexibility (Hubber & Ramseger, 2016) and functionality (Ismail & Abdullah, 2018) are the most important factors required for quality twenty-first-century learning spaces (Makela & Halfenstein, 2016), fulfilling the psychological, physiological and bio-physical needs, of the user (De Vrieze & Moll, 2018). New school building design identifies students’ preferences, transfers them to planning processes (Lefdal, 2023) and develops learner-centred spaces.

Integration of Technology

Digital transformation in the educational field has brought out a change in user behaviour (Noreiga et al., 2013); learners’ relationship to their learning (De Jong, 2021); and even the learning-teaching process (Kusmin & Laanpere, 2023). A large number of studies analysed the users’ experiences (Wang, 2023; Sardinha et al., 2020), and the effectiveness of online learning (Attalla et al., 2021). The development of online mobile classrooms (Pattanasith, 2016), simulated learning environments (Alfred et al., 2018), and gamification strategies (Raphael, 2016) indicates a high level of satisfaction among the users. Research on new technologies like metaverse-based learning (Dreamson & Park, 2023), Virtual reality (Riemann et al., 2020), virtual robotics (Chichekian et al., 2024) and the Internet of Things (Hwang et al., 2023) have been grown worldwide, to improve the overall quality of instruction (Wang et al., 2024). In smart learning spaces (Cao & Baki, 2024) students’ individuality, social

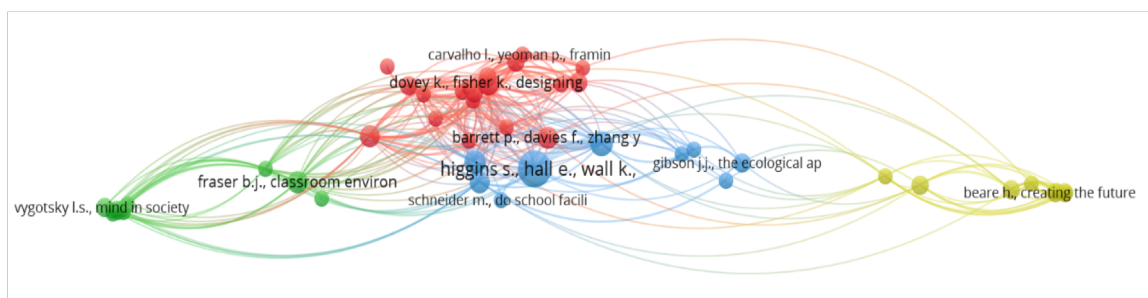


Figure 5 - Co-citation analysis of cited references.

Table 6 - Keyword occurrence analysis.

Rank	Keyword	Occurrences	Rank	Keyword	Occurrences
1	Learning Spaces	42	14	Participatory Design	5
2	Learning Environment	24	15	Architecture	4
3	Pedagogy	15	16	Psychosocial Learning Environment	4
4	School Buildings	13	17	Student Engagement	4
5	Higher Education	11	18	Active Transportation	3
6	Built Environment	10	19	Childhood Obesity	3
7	Classroom design	9	20	Collaborative learning	3
8	Children	8	21	E-learning	3
9	Covid-19	7	22	Environment Aspects	3
10	Physical Activity	7	23	Home Learning Environment	3
11	Distance Learning	6	24	Motivation	3
12	Online Education	6	25	Well-being	3
13	Active Learning	5			

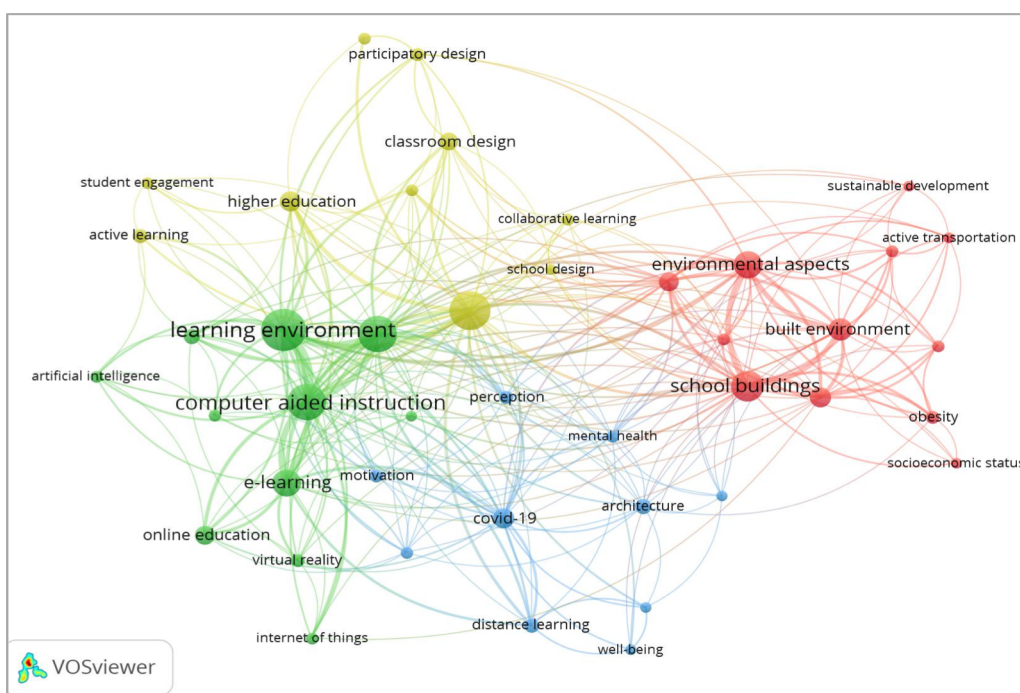


Figure 6: Network Visualization of all keyword occurrence.

interaction ability, thinking ability, creativity and cognition are increased to a remarkable extent.

Well-being

The well-being involves the individual's physical, mental and social wellness (Makela et al., 2014). Sustainable development goals include concern for the well-being of the learners (Kerr & Averill, 2024), and learning spaces to foster well-being (Maturana et al., 2021). COVID-19 led to inadequate physical activity (Triemstra et al., 2021) and a negative psychological impact (Panagiotis & Nikolina, 2024) on the students, diverting the researchers' focus towards the well-being of the students. The sense of well-being is significantly affected by classroom design and furniture (Perry et al., 2023), noise within and outside the classroom (Naude & Meier, 2019), large classroom sizes (Owoseni, 2020), sound pressure levels (Soares & Trombetta, 2016), and low luminance (Lekan-Kehinde & Asojo, 2021). The negative impact on students' well-being can be reduced through change in design (Brachtl et al., 2023).

Impact of Learning Spaces

The learning space, a secondary element of education (Szpytma & Szpytma, 2019) supports innovative pedagogies (Baars et al., 2023). Learning spaces impact students' cognition, behaviour and engagement in learning (Bojer, 2020; Munoz Cantero et al., 2016); attitudes and motivation (Getie, 2020); active learning (Riemann et al., 2020); satisfaction (Costa & Steffgen, 2020); and achievement (Choi et al., 2014). Most researches are based on user participation (Rönnlund et al., 2021), and has used a qualitative approach (Naude & Meier, 2019). Students perceive learning spaces to be meaningful, easily accessible, active, socially engaging and physically-emotionally comfortable (Nyabando & Evanshen, 2022).

4.4 Emerging Trends

The overlay visualization of author keyword occurrence shows the emerging trend in learning spaces. The growing emphasis on the achievement of sustainable development goals has transferred the focus of the researchers towards the well-being of the users, to enhance student outcomes and holistic growth. Peer learning plays an important role in the psychological and social well-being of the students. Another emerging research field is the use of Internet of Things (IoT) technology in learning spaces, with a growing emphasis on virtual reality and artificial intelligence as tools for creating immersive simulated learning experiences for students.

5. Conclusion

This bibliometric analysis highlights the tremendous growth, with the changing needs of the users, industry and the education system. But still, the research in the field of learning spaces is too low and there is a need to give more importance to the learning spaces in both the educational and architecture research. Researchers have conceptualized the connections between the spaces and the activities involved in the learning spaces, taking care of the technological developments in the educational field. The emerging need for various teaching methods and learning styles for students raises the importance of innovative learning spaces linked to pedagogy and student outcomes. The closure of schools due to COVID-19 led to the development of online learning, but online learning cannot bring the same learning experience as face-to-face learning. Learning spaces can motivate and engage students, to have better learning experiences. Learning space studies are mainly qualitative, with a questionnaire as a tool for assessment. School spaces have a deep impact on the mental-physical health of the students, which affects the well-being of the students and has a gap for future research. There is a need for studies in developing nations, as most of the studies are concentrated in developed nations.

The most cited publications relate to the impact of learning spaces on cognition, social aspects, and student engagement. The initial learning spaces studies were focused on pedagogy, and themes like active learning, collaborative learning and the teaching-learning process. Later, the researchers took an interest in the various aspects of the built environment like classroom design focussing on the participation of the users, and physical activities in the schools, for the better well-being of the students. Before the outbreak of the Covid 19, research was focused on the evaluation of learning spaces and the relationship between pedagogy and learning spaces. Later, after Covid 19, the research was more aligned towards online learning environments, distance learning, virtual learning environments, the effectiveness of digitalised blended learning and the integration of new technologies like virtual reality, artificial intelligence and mobile sensing. The latest themes that have evolved in the research are the innovative school building design, integration of technology, user mental, physical and social well-being and impact of learning spaces on user behaviour, attitude, outcome and satisfaction. These key themes provide a base for future research. New emerging themes include overall well-being and technological advancement in learning spaces. Changes in educational pedagogies, user needs and integration of technologies, require ongoing bibliometric analyses for tracking new emerging themes of research and developments.

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