School Design on Users' Responses

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Contributor: Sara Manca , Veronica Cerina , Valentina Tobia , Simona Sacchi , Ferdinando Fornara

This systematic review focused on the effect of the educational environment design on students' and teachers' performance, satisfaction, and wellbeing. Starting from a bulk of 1307 articles, a set of *N* = 68 empirical papers was selected and organized on the basis of four different content clusters, i.e., architectural building design and aesthetic features, indoor environmental features, classroom design, and school green spaces/outdoor spaces. From the analysis of research findings, the key role of pleasant, warm, and flexible learning environments emerged, for promoting both wellbeing and performance of users. More specifically, the presence of charming colors and pictures, ergonomic furniture, and adequate acoustic, thermal comfort, ventilation, and natural lighting have emerged as important features that school designers should care for. Furthermore, an integration of both indoor and outdoor learning situations showed to be effective for improving students' learning and wellbeing.

school architectural features | psychological responses | learning space | students' performance | users' wellbeing

1. Introduction

A total of 1307 articles were identified, 420 of which were immediately removed due to duplicate publications. A total of 887 studies were then screened through an analysis of the abstracts and 814 were considered unsuitable for inclusion (see exclusion criteria 1–4). Sixty-eight studies were reviewed through an analysis of the full-text and were finally selected and included in the review (64 relevant for the topic of each cluster and four studies moving across clusters). A summary of the literature review process is shown in Figure 1.

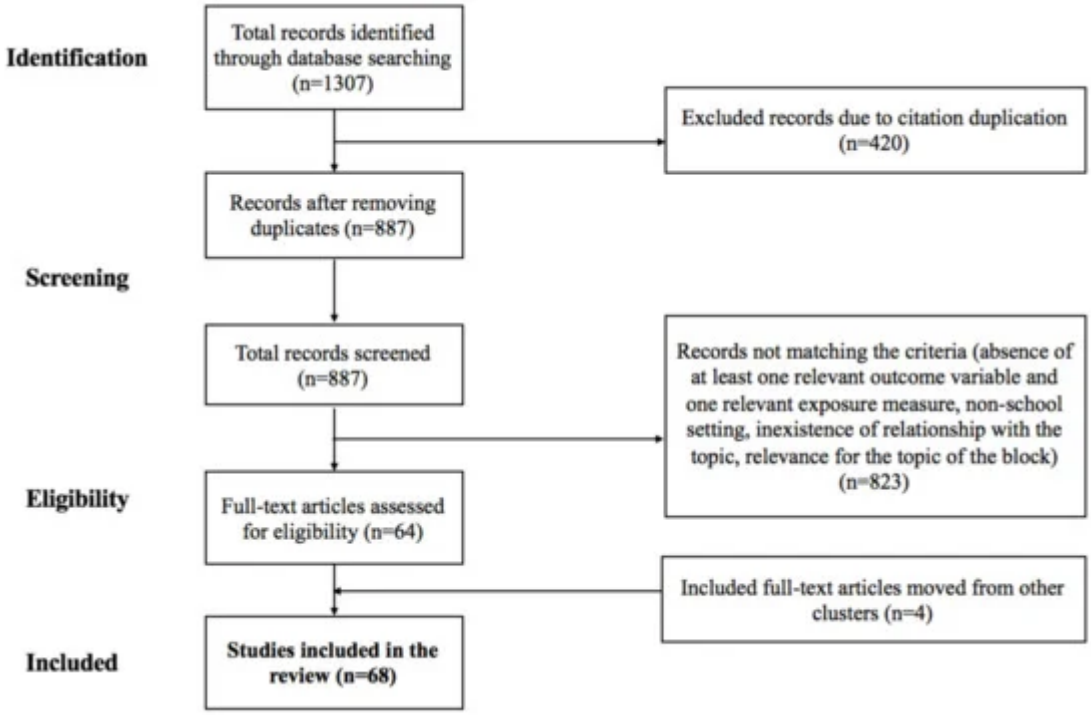

Figure 1. Summary of the literature review process.

Table 1 shows the variables considered by the studies that fulfilled the inclusion criteria for this review. *Indoor environmental features* of school buildings are the most considered cluster of exposure measures variables (Cluster 2), followed by the *outdoor and green areas* cluster (Cluster 4).

Table 1. Summary of the reviewed studies.

	Quantitative Study	Qualitative Study	Mixed Design	Total
School building/architectural design/aesthetic features	5	5	0	10
Indoor environmental features	19	1	2	22
Classroom design and furniture	2	8	2	12
Outdoor and green areas	4	18	2	24
Total	30	32	6	68

Table 2, Table 3, Table 4 and Table 5 report information about the reviewed studies for each of the clusters, specifying authors, research design, participants (number of schools involved, sample size, age, and country), exposure measures [1], outcome measures, and relevant results are reported. Following the graphical schematization used by a systematic review about the relationship between school furniture and students' performance, the effect of the exposure measure was classified as (+) when the effect resulted in an improvement

in the outcome variable, (−) when the effect was negative, (0) when there were no change, and (+/−) when the results were not clear [2] (p. 96).

Table 2. Studies on the effects of school building, architectural design, and aesthetic features.

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Age (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
1.	Cencič (2017)	Quantitative study	n = n.s. pp = 150 school leaders in primary education yr = 31—more than 61 c = Slovenia	Age of the school building (new building: Less than five years; old building: More than five years; or renovated school)	Evaluation of learning environment (factors: Imagination, creativity, feelings, language, music, logic and mathematics, space, movement, ecology, aesthetics, cooperation among students, respect, ethics and attitude towards the broader community)	**(0)** New and renovated schools were given less preferences over old buildings with respect to cooperation among pupils, language, and ethics, although with no statistically significant differences. (+) New schools only scored slightly higher than old and renovated buildings did in the factors of ecology, attitudes towards broader community, music, aesthetics, feelings, imagination, and space. **(−)** Their estimates of the assessed factors differ depending on the type of school building (new, old, renovated) only on the factors of movement, creativity, and

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Age (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						logic and mathematics in favor of old schools.
2.	Ghaffarzadeh (2016)	Qualitative study	*n* = 10 pp = 260 students, female yr = third year of secondary school c = Iran	Rating of physical environment (excellent, medium, or inappropriate) and type of schools (timeworn, new, or refreshed)	Learners' and teachers' educational behaviors; education discrimination	**(+)** The private schools with excellent physical environments were found to have a higher cooperative learning method than public schools with inadequate physical environments: Understanding; less cheating; considerable attention; reasonable teacher behaviors regarding learners' mistakes; student involvement in the teaching/learning process; cooperative teaching; meaningful learning; less stress; communicative language teaching (CLT).
3.	Lumpkin (2016)	Quantitative study	*n* = 15 primary school, *n* = 10 junior high school, *n* = 12 senior high school pp = n.s.	State of school facility (old or new buildings)	Academic achievement of students (measured by the mathematics	**(+)** Results indicated that the aggregate passing percentages on the mathematics and reading

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Age (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
			yr = fourth, eighth, ninth, and tenth grade students c = Florida (USA)		and reading subtests)	subtests increased when students attended a new 2000 UBC (Uniform Building Code) school facility.
4.	Slunjski (2015)	Qualitative study	*n* = 7 institutions Pp = n.s. yr = preschool c = Croatia	Spatial organization and structure of the school (e.g., size of the institution)	Quality of educational processes	**(+)** Inadequate size of early childhood education institutions—too large facilities aggravate the quality of the child's education, since they inhibit the possibility for the child to develop his/her identity.
5.	Stringer, Dunne, and Boussabaine (2012)	Quantitative study	*n* = 15 secondary schools pp = heads of the schools and their facility management representatives yr = n.s. c = UK	Rebuilding, refurbishment, renewal, or new opening school building	Users' perceived design quality of school (e.g., sense of place, orientation, clarity, efficiency, building performance)	**(+)** From the analysis and discussion of these results, it is suggested that the issues relating to site, which are the clarity of the building envelope and creation of a public presence, appear to have been resolved in the opinion of the survey respondents. Another area that appears to have improved greatly is circulation, that is how "easy [it is] to find your way around the

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Age (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						school." **(−)** However, the other areas of concern remain unsatisfactory. Material specification performed very poorly as did the quality of building maintenance.
6.	Duca (2012)	Quantitative study	*n* = 1 pp = 87 pupils and 8 teachers yr = third, fourth, and fifth grade of primary school c = Italy (Naples)	Characteristics of building and urban surroundings	"School usability," investigated in terms of effectiveness, efficiency, and satisfaction of school building (as possible indicators of learning outcomes)	**(−)** Learning activities, especially under the user's satisfaction point of view, are only relatively affected by buildings fully compliant with Italian regulations. On the contrary, many of the relevant characteristics are out of the regulatory field; inadequacies related mainly to a macro scale level (urban context) or to a micro scale level (technical devices, finishes, furniture).
7.	Leiringer and Cardellino (2011)	Multiple case study	*n* = 4 pp = n.s. (head teachers, teachers, and other related staff) yr = n.s.	Building design (design of school environments, e.g., open and transparent designs)	Teaching and learning	**(−)** Open and transparent designs (e.g., interior windows or the lack of interior walls) are encouraged and

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Age (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
			c = Sweden and Denmark			flexible learning environments are consistently promoted as facilitating changes in teaching and learning approaches. However, there was agreement amongst teachers and parents that the extreme transparency of the space had a negative effect on certain pupils' behavior (e.g., more distraction, worse acoustic, less privacy for the pupils and teachers)
8.	Cuyvers, De Weerd, Dupont, Mols, and Nuytten (2011)	Quantitative study	*n* = 14 secondary schools pp = 2032 students yr = 14–15 c = Belgian region of Flanders	Impact of school infrastructure	Wellbeing of students	**(+)** Scores on wellbeing were significantly lower among students attending schools with poor quality infrastructure and schools with low scores on both variables ("to the extent possible, possible the classrooms open onto a (green) outside area" and "the school building provides well-integrated ICT and easy access to various sources for

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Age (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						research"). Female students were more sensitive to school infrastructure than their male colleagues and ninth grade students were more sensitive than 10th grade students.
						(+) When the school is constructed and used in flexible and responsive ways, students begin to think of themselves as part of the place. The place, in turn, becomes part of

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
1.	Mendell, Eliseeva, Davies, and Lobscheid (2016)	Quantitative study	*n* = 28, 150 classrooms pp = 5046 (English) +5455 (maths) yr = elementary schools c = three California school districts (USA)	Daily classroom ventilation rates (VRs) from real-time indoor carbon dioxide measured by web-connected sensors	Learning (individual-level scores on standard tests in math and English)	**(+)** Findings suggest potential small positive associations between classroom VRs and improved learning in English and Math among young students, but associations were of variable magnitude and with few CIs excluding the

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						null. VRs were in most cases more strongly associated with higher test scores in the district where the VRs were very low.
2.	Petersen, Jensen, Pedersen, and Rasmussen (2016)	Quantitative study	*n* = 2 (two classrooms at each school) pp = 82 yr = 10–12 c = Denmark	Increased classroom ventilation rate (exposition to either recirculated air or fresh air)	Performance of children in four different tests (addition, number comparison, grammatical reasoning, and reading and comprehension)	**(+)** Increased ventilation rates in classrooms have a positive effect on short-term concentration and logical thinking of children performing schoolwork. Individual pupils' performance was significantly improved in four of four performance tests when the outdoor air supply rate was increased, and CO_2 concentration was decreased. **(−)** Increased outdoor air supply rate did not have any significant effect on the number of errors in any of the performance

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						tests. **(+)** Results suggested that the study classroom air was perceived more still, and pupils were experiencing less pain in the eyes in the recirculation condition compared to the fresh air condition.
3.	Lee, Kwon, and Lim (2016)	Field experiments	*n* = 4 classes pp = students yr = n.s. c = Korea	Use of an intelligent lighting control system based on context-awareness (that recognizes the locations and behaviors of the teacher and students automatically by means of sensors; grasps the current class context; and creates appropriate lighting environments accordingly)	Learning efficiency	**(+)** The lighting condition was comfortable and effective for learning efficiency as it was in the comfortable range of Kruithof's curve. This indicates that when applied to a classroom environment, the suggested system contributes a lot to learning efficiency improvement.
4.	Akhtar, Anjum, and	Quantitative study	*n* = 4 pp = 100 students and 20	Noise pollution around	Students' and teachers' performance	**(−)** All four schools have noise level

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
	Iftikhar (2013)		teachers yr = 10–13 (students) c = Pakistan	educational area (noise level indoors-classrooms and outdoors-playgrounds)	and comfort (e.g., learning ability, social interaction, conflicts, headache, tiredness, attention)	more than World Health Organization recommended allowable noise level. All Dependent Variables are adversely affected by high classroom noise. High background noise has a major negative impact on students' performance (most of the schools are located close to main roads).
5.	Sleegers et al. (2013)	Quantitative study	*n* = 2; 1; 6 pp = 98; 44; 55 yr = Elementary c = Netherlands	Lighting conditions (with vertical illuminances between 350 lux and 1000 lux and correlated color temperatures between 3000 and 12,000 K)	Concentration of elementary school children	**(+)** The results indicate a positive influence of the lighting system on pupils' concentration. The findings underline the importance of lighting for learning
6.	Chan, Li, Ma, Yiu, and McPherson (2015)	Quantitative study	*n* = 37, 146 classrooms pp = n.s. yr = kindergartens, primary schools, secondary schools, and	Noise levels and teacher speech-to-noise ratio	Learning and teachers' vocal health	**(−)** All except one classroom were exposed to excess background noise over the recommended level of 50 dBA for occupied

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
			special schools c = Hong Kong			classrooms. Teachers increased their vocal effort to overcome the high noise levels in classrooms so that their students could hear them. It could have adverse implications for student learning and teachers' vocal health.
7.	Mealings, Demuth, Buchholz, and Dillon (2015)	Quantitative study	*n* = 1 pp = 22 yr = 5–6 c = Australia	Two listening conditions of intrusive classroom noise. In one condition classes were engaged in quiet activities (e.g., whole-class teaching), and in the other condition classes were engaged in noisy activities (e.g., group work with movement).	Children's speech perception, listening abilities	**(−)** Children's performance accuracy, number of responses, and speed were lower in the noisy condition compared with the quiet condition. In addition, children's speech perception scores decreased the farther away they were seated from the loudspeaker.
8.	Brännström et al. (2017)	Quantitative study	*n* = 4 pp = 149 yr = 9–13 c = Sweden	Acoustic environment of the schools	Children's perception of the acoustic	**(-)** Crowded spaces are most challenging; the

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
					environment of their school	children themselves generate most of the noise inside the classroom, but it is also common to hear road traffic noise and teachers in adjoining classrooms. The extent of annoyance that noise causes depends on the task but seems most detrimental in tasks wherein the demands of verbal processing are higher. Finally, children with special support seem to report that they are more susceptible to noise than the typical child.
9.	Punnoose, Arya, and Nandurkar (2017)	Quantitative study	n = n.s., local regular English medium schools and multidisciplinary centers pp = 30 children who have been diagnosed with learning disabilities (LD) and control	Presence of quiet vs. noise (four-talker babble)	Speech perception (word recognition scores) in children with LD	**(−)** Children with LD show increased speech recognition deficits in the presence of noise. Moderate amount of background noise can interfere with

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
			group has 45 typical children yr = 9–12 c = Mumbai			speech perception and can impair educational outcomes in children, with greater effect on younger children.
10.	McKellin, Shahin, Hodgson, Jamieson, and Pichora-Fuller (2011)	Quantitative study	*n* = 1 pp = 24 yr = third, fifth, seventh grades c = Canada	Noise in regular classroom activities	Structure and substance of learning in English language (students' grammatical and discourse structures, organization of conversation, and development of conceptually complex interaction)	**(−)** Noise levels impeded the intended development of complex conversational interactions and collaborative learning.
11.	Santos, Seligman, Souza, and Rossi (2013)	Quantitative study	*n* = 4 pp = 87 children yr = 8–10 c = Brazil	Sound pressure levels in classrooms and changes on acoustic admittance	Auditory skills in learning process	**(+)** High sound pressure levels in classrooms do not interfere in children's auditory skills, in the learning process tested using the Staggered Spondaic Word Test, an instrument used to detect auditory processing problems in children with learning

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						demoted. **(+)** G1 (group not exposed to levels higher than 80 dB) has showed better results in phonemic decoding; (−) G1 has shown worse results in codification and organization sub profiles.
12.	Connolly, Dockrell, Shield, Conetta, and Cox (2013)	Quantitative study	*n* = 6 pp = 2588 English secondary school pupils yr = 11−16 c = UK	Acoustical features of schools	Pupils' impressions of their school's acoustic environment (to ease of hearing in school spaces, sensitivity to noise, the consequences of noise in the classroom, and annoyance to intermittent noise)	**(−)** Pupils who reported additional learning needs reported being significantly more affected by poor school acoustics than pupils reporting no additional learning needs. Older pupils were significantly more sensitive to noise annoyance and to the consequences of poor acoustical conditions on their learning and behavior than younger pupils. **(+)** Pupils attending suburban

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						schools featuring cellular classrooms that were not exposed to a nearby noise sources were more positive about their school acoustics than pupils at schools with open plan classroom designs or attending schools that were exposed to external noise sources.
13.	Dockrell and Shield (2012)	Quantitative study	*n* = 8 pp = 393 (survey—baseline and follow-up installation); 186 (experimental study); 14 teachers of classrooms (with sound-field systems) yr = 8−11 c = UK	Acoustical features of classrooms (installation and use of sound field systems)	Students' and teachers' perceptions of classroom environments and objective data evaluating change in performance on cognitive and academic assessments with amplification over a six-month period.	**(+)** Both teacher ratings and student performance on standardized tests indicated that sound-field systems improved performance on children's understanding of spoken language, especially in classes with poorer acoustics.
14.	Nilforoushan, Hanna, Naeini, and	Quantitative study	*n* = ns. pp = n.s. students, teachers, head	Illumination in classroom (e.g., impact of daylight)	Student performance and health	Daylight has an impact on performance and health:

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
	Mozzafar (2013)		teachers, and architects yr = primary school c = Glasgow (UK)			**(+)** Light levels did affect space utilization in classrooms and pupils seemed happier and more active in sunny classrooms than in shaded ones. **(+)** In general, the availability of daylight in classrooms was reliably associated with an increase in student performance and learning rate of somewhere within the bounds of 7% to 37%.
15.	Mott, Thomas, and Burnette (2017)	Case study	*n* = 1 pp = a teacher and her classroom yr = third grade c = USA	Use of a dynamic lighting system in classroom (color, temperature, and luminosity created four light settings: Focus, energy, calm, and normal)	Educational performance in the classroom (cognition, motivation, and concentration)	**(+)** The focus setting helps students to settle in and concentrate much easier than any of the other lighting modes.
16.	Ljung, Sörqvist, and Hygge (2009)	Quantitative study	*n* = 1 (nine classrooms) pp = 187 pupils	Classroom noise (irrelevant speech in	Children's learning (reading and	**(−)** Road traffic noise was found to impair reading speed

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
			yr = 12−13 c = Sweden	classrooms and road traffic noise adjacent to schools)	mathematical performance)	and basic mathematics. **(0)** No effect was found on reading comprehension or on mathematical reasoning. Irrelevant speech did not disrupt performance on any task.
17.	Riley and McGregor (2012)	Quantitative study	n = n.s. pp = 31 children yr = 9−10 c = USA	Effects of noise (noise vs. quiet) and speech style (plain vs. clear)	Word learning in typically developing school-age children	**(+)** Children who were trained in quiet learned to produce the word forms more accurately than those who were trained in noise. **(−)** Noise limits expressive vocabulary growth in children, reducing the quality of word form representation in the lexicon. Clear speech input can aid expressive vocabulary growth in children, even in noisy environments.
18.	Ana, Shendell,	Quantitative study	*n* = 8 pp = 400	Noise levels in classroom	Adverse noise-related health	**(−)** Over 60% of respondents

Table 4. Studies on the effects of classroom design and furniture.

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
1.	Benes, Finn, Sullivan, and Yan (2016)	Mixed-methods design, quantitative and qualitative (written survey and semi-structured interviews)	n = n.s. pp = 17 teachers yr = average age of 39.7 c = Massachusetts and New Hampshire (USA)	Possibility to move in the classroom (space and layout)	Teachers' perceptions about benefits of using movement in the classroom	**(+)** Teachers discussed that students enjoy moving in the classroom and that they use movement - to increase students' engagement with their academic content; - to give the students a break before returning to academic content; - to help students in refocusing; - to focus students and to improve learning; - to help students retain the information and increase their ability to learn and remember material.
2.	Durmuş (2016)	Qualitative study	n = n.s. pp = 48 elementary school teachers and 6 school	Features of physical environments, instructional technologies, materials	Participants' views on learning environments (requisites to enable	**(-)** Participants underlined the need for separate classrooms for each course;

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
			administrators yr = n.s. c = Turkey		learners to construct knowledge)	- Beside the seating arrangement, classroom sizes were criticized. There is no place for walking, lying and reading books or drawing, searching or creating a learning center **(+)** Teachers suggest decreasing the number of students in a classroom to create a place for free-time activities; - If the activities are conducted on carpet floor, the feeling of safe and comfortable learning environment leads to feeling of enthusiasm from their point of view; - Teachers also expressed that they need personal cabinets to hold exam papers.
						influenced not only by the

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
3.	Liou, Marsh, and Antrop-Gonzalez (2016)	Qualitative study	*n* = 1 pp = n.s. students who had historically been marginalized in academic contexts yr = 11th- and 12th-graders c = California (USA)	Spatial arrangement of learning opportunities as manifestations of teachers' and students' expectations in learning contexts.	Spatial behaviors of teachers and students	**(+)** The spatial behaviors of students and teachers are greatly influenced by the expectations they had of each other, and by extension, the spatial arrangement of learning opportunities as manifestations of their expectations in learning contexts.
4.	McAllister and Maguire (2012)	Qualitative approach	n = n.s. pp = Autism spectrum disorder (ASD) teaching staff yr = n.s. c = Northern Ireland	Utilization of a design kit to describe an ASD-friendly classroom layout	A better learning environment project	**(+)** The use of modelling with the ASD Classroom Design Kit at an initial design phase encouraged the teachers to 'buy into' the design process. - The teachers were able to share their ideas with the architects, and the architects got a valuable insight into *why* those choices were being made.
5.	Martins and Gaudiot (2012)	Qualitative study	*n* = 2 pp = deaf students and teachers yr = from kindergarten to middle school c = Brazil	Attended learning environment	Deaf students' perceptions about comfort in their learning environment (referring to lighting, acoustics, accessibility, visualization	**(+)** To improve the learning environment for deaf students some suggestion are: - Color signal system above the blackboard with a switch beside the teacher desk to alert about

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
					and detection, warning signs, furniture, and layout of the classroom)	attention, danger, breaks, end of classes, etc.; - Layout in circle shape for classes with fewer students and in a steps audience shape for more students. If it is an inclusive class the deaf student should be in the second line, which allows him to see the reaction of the front students during the questions/answers, or when in front in diagonal, in relation to the class. In either case no obstacle should be between him and the teacher or interpreter and the blackboard; - The blackboard should be big enough to keep the information for enough time to be

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						written by the deaf students; - Put corner concave mirrors so the students can see and follow his colleagues; - The furniture such as desks and chairs are separated to prevent dropping materials during sign language use; - Avoid sun glare in the blackboard and class with curtains or brise soleils outside; - Forecast the use of electronic material for visual explanation of the subjects, such as computers, overhead projector screens, etc.
6.	Maheshwar and Jawalkar (2014)	Quantitative study	*n* = 2 elementary schools pp = 100 students (50	Evaluation of existing school furniture and developed	Subjective comfort and satisfaction evaluation	**(+)** New designs are described as acceptable, economic, multi featured, and serving to the ergonomic

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
			for each one) yr = 4−7 c = n.s.	prototypes (e.g., with ideal school chairs' parameters for different physical dimensions of students)		requirements of kids in that age range. - The painting of such furniture with attractive colors, cartoons, and pictures would further make the design fascinating and admirable amongst the target population.
7.	Smith (2013)	Report	n = n.s. pp = n.s. yr = K−12 c = n.s.	Environmental design of classroom and building design factors	Student performance and learning	**(+)** Student academic performance is strongly influenced by the level of classroom and school building design quality. - Previous studies cited in the report have in fact showed that: - Chair design, air quality, and noise as primary classroom design factors needing improvement, and provided an estimate that poor classroom design and maintenance can lead to decrements of 10%–25% in

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						student performance; - Classroom furniture properly designed for children improves on-task behavior, promotes better sitting and standing postures, reduces back pain and other musculoskeletal complaints, increases trunk muscle strength, and improves overall academic marks. - Another emerging furniture trend is a movement away from straight-row ranks of student desks to clustered or U-shaped desk arrangements that favor group discussion and cooperative learning

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
8.	Gonçalves and Arezes (2012)	Qualitative study	n = several pp = 20 children yr = second to fourth grade of first cycle of education c = Portugal	Type of furniture: (a) Traditional furniture (flat table and chair with 5º backward tilted); (b) with the use of a traditional chair (5° backward tilted) and table 12° tilted; (c) with a chair with seat 12° sloped forward and a table top 12° tilted.	Children's wellbeing (neck and back postures)	**(+)** The best posture for the trunk is achieved by using a combination of furniture with tilted tables and seats. - The school furniture should be designed to accommodate the natural resting position, in which - opposing muscles are well balanced. The resulting posture will tend to improve performance, efficiency, and children's wellbeing.
9.	Woodcock, Woolner, and Benedyk (2009)	Case study (field study, interviews, observation, qualitative and quantitative approach)	n = n.s. pp = n.s. yr = primary school c = UK	Application of Hexagon-Spindle (H-S) model classroom design (that is, a low sensory room, stripped, and equipped with furniture and places that would enable individual, supervised, and joint working. A tailorable	Benefits in children with special education needs, autistic spectrum disorder (e.g., time on task, or engaging in imitative behavior)	**(–)** A 'one size fits all' educational environment was not considered appropriate due to the potential wide range of needs that had to be accommodated. It is important to determine the range of tailor ability that had to be accommodated. **(+)** The room was positively viewed by all groups—children were willing to try new experiences and engage in social play. Two parents noted improvements in

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
				lighting system, full size display screen, movement area, and six basic learning modules were provided)		behavior and an increase in verbalization.

From other clusters:

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
1.	Yates and Sullivan (2017)	Qualitative study	*n* = 3 pp = 11 school staff and local members yr = Elementary, middle school, K−8 c = Southwest Montana (USA)	Development of school gardens and garden-based curriculum	Impact of school garden on the students and on the local community	**(+)** Positive impact of school garden on the students: Higher engagement in lessons, improved students' health.
2.	James and Williams (2017)	Qualitative study	*n* = 1 pp = 56 students yr = seventh and eighth grade c = Rocky Mountain West (USA)	Outdoor education experience	- Engagement in experiential outdoor education; - Perceived value of outdoor education	**(+)** A total of 79% of participants indicated that the outdoor education camp was worthwhile; involvement and love of learning also in disinterested and apathetic students; students' understanding was deepened more as their critical thinking skills were developed than
						aspiration for still, quiet bodies during learning, a

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						in traditional lessons; enhanced sense of independence and responsibility.
3.	Christie, Beames, and Higgins (2016)	Qualitative study	*n* = 3 pp = 150 students and 10 teachers yr = 11−14 c = Scotland	Outdoor Journeys program (learning in an outdoor context, as school-grounds and local surroundings)	- Enjoyment of participants in activities; - Teachers' perspectives on the pupil experience and the learning process; - Teachers' willingness to implement outdoor program in the future.	**(+)** Some 89% of students enjoyed Outdoor Journeys; continual dialogue between the teachers and pupils as they worked together; two of three sample schools felt increased pupils' critical thinking skills; a teacher of one school reported that interpersonal skills were also developed.
4.	Gomboc (2016)	Qualitative study	n = n.s. pp = n.s. yr = 9 c = Slovenia	Teaching outdoor, in a natural environment (specifically, a park near the school)	- Learning of students; - Enjoyment of participants in outdoor activities, - [illegible] program.	**(+)** All the children said that they would like to learn in nature again; children explored actively the natural environment.
3.	Aturupane, Glewwe, and Wisniewski (2013) B2	Quantitative study	*n* = 939, 140 pp = 16.383 (NEREC), 2653 (NEC) yr = primary	School Quality (e.g., student desks, blackboards, computers,	Learning in primary schools—reading and math skills—and students'	**(+)** The only school physical facility or equipment variable with any significant impact is desks.

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
					Desire to learn in nature more often	
5.	Gehris, Gooze, and Whitaker (2015)	Qualitative study	n = n.s. pp = 37 teachers (20 lead and 17 assistant) volunteered to participate yr = n.s. c = Eastern Pennsylvania (USA)	Head Start program (movement experiences for about 1100 pre-school aged children, 40 classrooms)	Teachers' perceptions about the importance of movement for learning in children; - Best types of settings to support children's movement experiences	**(+)** Moving outdoors promotes learning: Contact with nature engages children's senses, which helps them to learn; children learn by being outside interacting with their community.
6.	Sharpe (2014)	Qualitative study	*n* = 1 pp = 9 pupils, 2 charity staff, 2 teachers, 5 parents/carers yr = 10–11 (students) c = South East of England (UK)	Growing Together Schools Program (community gardening program)	- Learning; - Personal independence; - Changes in everyday practice; - Friendship	**(+)** The program promoted: Academic and social skills goals creating great fun and enjoyment in pupils; growth of pupils' self-confidence (personal independence); increased new friendship and teamwork.
7.	Mart, Alisinanoglu, and Kesicioğlu (2015)	Quantitative study	n = n.s. pp = 156 preschool teachers from 81 different cities yr = n.s. c = Turkey	Presence of school garden	- Use of school garden; - Perceived importance to take more places for garden	**(+)** School garden are used for play and for curricular activities (movement, science, art, language, music, math, literacy preparation).

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
					activities in Preschool Education Programme	
8.	Bortolotti, Crudeli, and Ritscher (2014)	Case study descriptions and discussion	n = n.s. pp = about 40 in-service teachers yr = n.s. c = Italy	Training for teachers in outdoor learning (OL)	Teachers' perceptions about OL and training to practice it	**(+)** Teachers perceive positively the usefulness and impact of training in OL, as it tends to improve significantly the quality of relationship between themselves, children, families, and the out-of-doors settings; OL involves reflectivity and pragmatic points; OL fosters social and personal wellbeing.
9.	Dowdell, Graya, and Malone (2011)	Qualitative study	*n* = 2 early childhood centers pp = 12 children yr = 2−6 c = Sydney	Presence/absence of nature in outdoor environment of the center	Children's play, learning, and social behavior	**(+)** Natural environments support children's imaginative play, the development of positive relationships.
10.	Carrier, Tuguria, and Thomson (2013)	Mixed-methods research study, qualitative (interviews/observations) and quantitative (survey)	*n* = 2 pp = 49 students and teachers and school's principals yr = fifth grade classes of elementary	Environmental and outdoor vs. traditional education (pre-post test)	Students' science knowledge, environmental attitudes, and outdoor comfort levels (QNT); views on science education and environmental issues (QLT)	**(+)** All students showed growth in science knowledge; significant differences were found with respect to students' environmental

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure		Relevant Results
			school c = USA				attitudes; (−) No significant differences were found for students' outdoor comfort level (pretest and posttest).
11.	Borić and Škugor (2014)	Quantitative study	n = n.s. (12 classes) pp/yr = 319 students of elementary school c = Osijek (Croatia)	Research-based outdoor teaching (experimental group, E.G.) vs. lecture-based teaching (control group, C.G.)	Students' motivation, participation, and learning (knowledge, abilities, and skills)		**(+)** High motivation, satisfaction and eager participation in E.G.; also, problem-solving abilities and skills are significantly improved; group work and cooperative learning are lower in C.G; **(−)** The level of students' reproductive knowledge remains the same in E.G.
12.	Flom, Johnson, Hubbard, and Reidt (2011)	Two case studies	n = n.s. pp = n.s. yr = primary level children; high school-level students c = USA	Outdoor problem-solving counseling program; participation to an extracurricular fishing club, especially for more disadvantaged students (for ethnicity, income, disability, and low involvement to school activities)	1) 2)	n° of discipline referrals; student connectedness (interpersonal and coping skills; academic outcomes emphasized goals,	**(+)** Improvement of social relationships with peers and general reduction in discipline referral; high involvement in club activities, high inclusivity.

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
					time/task management, and problem solving; and outcomes related to careers addressed both career awareness and employability skills)	
13.	Dhanapal and Lim (2013)	Mixed-methods research study, qualitative (observations) and quantitative (quiz test and survey questionnaire)	*n* = 1 pp = 34 students yr = third grade c = Malaysia	Type of learning (indoor vs. outdoor before)	Students' academic performance and students' point of views about the integration of both indoor and outdoor learning in science	**(+)** Indoor and outdoor learning complement each other in improving students' academic performance.
14.	Feille (2013)	Qualitative study	*n* = 1 public urban school and 1 small private school pp = 3 teachers yr = n.s. c = North Texas (USA)	Experience of learning to teach in the school-yard and school garden	- Teachers' reactions and feelings in garden and outdoor teaching; - Teachers' experience in garden education	**(+)** Garden education allows students to see things and make connections that teachers cannot provide them in the classroom; nature can provide intense experiences of learning, inspiring students' curiosity and intent to learn.
15.	Brockman, Jago, and	Qualitative study	*n* = 4 primary schools	Children were provided with a	Children perceptions of active play (self-	**(+)** Easily-accessible green

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
	Fox (2011)		pp = 77 yr = 10−11 c = Bristol (UK)	definition of active play, which was "any activity which takes place outdoors in your own free time which isn't organized by an adult."	reported motivators, barriers, and facilitators)	spaces were reported to be regularly used for active play.
16.	Eick (2012)	Qualitative study	***n*** = 1 pp = 1 teacher and her class (22 students) yr = third grade of elementary school c = (USA)	School's outdoor classroom and a nature-study approach	- Teacher's evaluation of outdoor approach; - Children's state test results in reading and grammar for meeting annual yearly progress	**(+)** Science and language arts connected to the outdoor classroom were a big motivator for lower achieving children, whose self-esteem was boosted through outdoor experiences; high-stakes test results affirmed this approach through comparable high reading scores to other third grade classrooms.
17.	Paisley, Furman, Sibthorp, and Gookin (2008)	Case study (survey, qualitative data)	n = n.s. (six different National Outdoor Leadership School—NOLS—branches) pp = 441 yr = average of 24.9 years c = USA	Participation to a NOLS course	Learning of six targets: Communication, leadership, small-group behavior, judgment in the outdoors, outdoor skills, and environmental awareness	**(+)** Interaction with the physical environment may facilitate creation of student-oriented mechanisms for learning; immersion in and interaction with the natural *and* social environments may have direct

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						effects on learning for certain students.
18.	Carrier (2009)	Quantitative study	n = n.s. pp = 109 students yr = fourth and fifth grade c = USA	Experimental (schoolyard) and traditional (classroom) condition classes	Environmental (a) knowledge, (b) attitudes, (c) behaviors, and (d) comfort levels	**(+)** Gender differences in learning styles; boys demonstrated statistically significantly greater gain scores in the outdoor treatment group than in the traditional classroom curriculum for all four outcome variables. Boys also scored statistically significantly greater in the treatment group on attitudes and behaviors than did girls in that treatment group.
19.	Stan (2010)	Qualitative study	*n* = 14 school groups pp = n.s. school children, teachers and the center staff yr = 6−12 (students) c = South-East England (UK)	Control, power, orders, and instructions of facilitators in outdoor education	Learning experience of children	**(+)** When control was exercised over the pupils taking part in outdoor activities, this impacted on the pupils' learning experience in a negative way, since the desired learning outcomes did not appear to be achieved.

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
[3][4] [8] 20.	Waters and Maynard (2010)	Qualitative study [9][10] [12]	*N* = 1 [5][6] pp = n.s. students and teachers yr = 4−7 c = Wales (UK)	Visit at a local country park (having several natural elements) as part of an outdoor learning project [13][14]	Learning and involvement [11] [16]	**(+)** Children often expressed their interest with awe and wonder; value of a natural space with multiple, flexible features for stimulating children's interest. [15] [17]
21.	Hanvey (2010)	Qualitative study	*n* = 1 pp = n.s. yr = 5 c = Texas (USA)	Utilization of an outdoor prop box	Learning and socialization and children's emotional responses	**(+)** Experience not only enabled the children to practice and extend academic skills they were learning indoors, but also enhanced their social skills; children adopted conflict resolution techniques when trouble arose and became responsible as they restored the prop box taking turns with the materials.
22.	Carrier (2009)	Qualitative study [18]	*n* = 1 pp = 14 preservice teachers yr = n.s. c = USA	Outdoor field experiences teaching science lessons to elementary school-age students	Their feelings of efficacy in teaching science; recognition of the potential for using the outdoor setting to teach science; intent to include outdoor education with future students.	**(+)** Twelve of the 14 pp described students' enthusiasm; - Participants shared enthusiasm that seemed to initiate with the

As regards the measures, the initial search found either self-report or objective measures of effects of school building design on school users, and only one study using objective measures was identified [18], specifically students' scores at mathematics and reading subtests. Other studies used either one or more of the following types of self-report measures: Teachers' and/or students' evaluation of learning environment (three), educational behaviors (two), design quality and school usability (two), wellbeing (one), and aspirations for the future (one). The most studied outcome variable was learning evaluation (i.e., students' achievement and performance), whereas student drop-out rate was not examined in result studies.

As for the countries, the studies were mostly (70%) conducted in Europe, specifically two in the UK (20%) and the others in other different European countries. The remaining three (30%) studies were conducted in North America

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						students and then spread to the preservice teachers; - All preservice teachers expressed some intent to use outdoor activities; - The preservice teachers' increased comfort in teaching science as a result of their field experiences emphasizes the power of modeling and the positive impact of their observing students' excitement
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ools, two of middle schools, four of both primary and middle school, four of post-middle school and one of unspecified age) and the remaining five studies sampled both students and teachers (22.7%).

As for the study design, different methodologies were used across the 22 papers of this cluster (see Table 1). In 19 studies (86.4%), effects of indoor environmental features were detected by quantitative methods (i.e., survey, experiment, and field studies), two studies (9%) used a mixed design (both quantitative and qualitative methods), and the remaining one study used qualitative methods (collection of the teachers' data).

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
						about learning science.
23.	Lloyd and Gray (2014)	Field study (case study)	n = n.s. pp = n.s. Indigenous students and parents yr = primary school c = Australia	Outdoor education	Learning	**(+)** Partnerships with Indigenous locals in facilitating outdoor education experiences are an excellent way to invite community members into schools, their knowledge and practice in the outdoors being invaluable.
From other clusters:						
1.	Anthamatten, et al. (2011) B1	Quantitative study	*n* = 3 × 3 elementary schools (recently-constructed "Learning Landscapes" (LL) schoolyards/LL schoolyards with older construction/un-renovated schoolyards) pp = n.s. elementary school students yr = 6−11 c = USA	Schoolyard renovation program ("Learning Landscapes" (LL) program), time of participation to the renovation program	Children physical activity in the schoolyard (before school, during school recess, after school, and on weekends) [20]	**(+)** Overall utilization was significantly higher at LL schools than at un-renovated schools for most observation periods. **(−)** Notably, LL renovation had no impact on girls' utilization on the weekends, although differences were observed for all other periods. There were no differences in

1.3. Effects of Classroom Design and Furniture on Students' and Teachers' Psychological Responses

Starting from 1307 total articles, this cluster identified 108 initial papers, but only 81 were reviewed due to duplicate publications. Twelve articles were finally included, of which three studies came from other clusters (Table 4).

As for the sample, five studies (42%) recruited participants from students (specifically, from elementary schools), three (25%) sampled staff (among teachers, school administrators, and other related staff), and the remaining four studies sampled both students and teachers (33%).

N.	Authors	Research Design	Participants: Number of Schools (n), Sample (pp), Ages (yr), Country (c)	Exposure Measure	Outcome Measure	Relevant Results
					[22]	rates of activity for any comparison. With the exception of the number of boys observed, there was no statistically significant difference in activity when recently constructed LL schools are compared to LL schools with older construction dates and there was no difference observed in comparisons of older LL with unrenovated sites.

Overall, the research literature on this cluster has been definitely characterized by the predominance of qualitative data, collected through interviews (individual or group ones) or observations, or derived from the realization of case studies. The primacy of self-report measures as outcome variables is another distinctive feature of this cluster. The presence of studies addressing the needs of specific students' categories (in particular children from primary schools, but also deaf or autistic students) could be related to the fact that the spatial level of analysis of this cluster is more circumscribed and focal than the others, representing a sort of microsystem for the user, as highlighted by the multiplace approach (see [23][24][25]. In other words, the classroom environment being the most direct, central, and thus meaningful subsystem of the school environment in the experience of students and teachers, then this spatial level should be particularly cared for in order to respond to differential needs.

As for the previous clusters, it is quite difficult to make comparisons across studies, given the predominance of qualitative studies as well as the high variability in construct operationalization, sample size and characteristics, kinds of techniques and tools (often ad hoc ones, not previously validated). Future research should investigate the potential role of socio-demographic variables (e.g., gender) and socio-psychological dimensions (e.g., interpersonal distance, intra-group and inter-group dynamics, social norms) as potential moderators of the relationship between the "objective" classroom environment features and users' responses.

1.4. Effects of School Green Spaces or Outdoor Spaces on Students' and Teachers' Psychological Responses

Starting from a total of 1307 papers, this cluster identified 199 initial articles, 143 of which were reviewed due to duplicate publications. Twenty-four articles were finally included, one study of which came from another cluster

(Table 5).

Concerning the sample, seven studies (29%) recruited participants who were students (one of which was attending early childhood education, four of which were attending primary school, one from middle school, and, finally, one with a sample of primary school students and another sample of high school students), nine studies (38%) sampled staff (among teachers and/or school principals) and/or other local members (parents, careers, charity staff), and the remaining eight studies sampled both students and teachers (33%).

As regards the study design, a range of different methodologies were used. In 18 studies (76%), effects of the presence of school activities in outdoor education form were measured by using qualitative methods (multi case studies, field experiments, semi-structured individual/group interviews, observation, and focus groups), four studies (17%) used quantitative methods (survey, experimental, and quasi-experimental studies), and the remaining two studies (8%) used a mixed design (both quantitative and qualitative methods).

About the measures, all studies used self-report measures (i.e., students' and teachers' perception of impact of outdoor education on learning, involvement, and enjoyment of participants), six of these used also objective measures (i.e., science knowledge assessment, knowledge test scores, students' academic performance).

As for the countries, 50% of studies were conducted in North America, 33% of studies were conducted in Europe (three in England, one in Scotland, one in Wales, one in Slovenia, one in Italy, and one in Croatia), and the remaining 17% of studies were conducted in Australia (two) and Asia (two).

Most of the findings (89%) presented positive (+) results, whereas the remaining 11% showed negative (−) results. The most examined outcome variable was learning evaluation, which referred to both the physical activity and the outdoor teaching experience.

Overall, if compared to the previous ones, this cluster of studies fruitfully integrate different perspectives and methodologies, revealing a quite consistent pattern of results: The opportunity to use outdoor spaces and facilities for outdoor teaching proved to be positively related to a wide range of variables. Importantly, these outcomes are not exclusively referred to performance in curriculum activities but also to relevant social skills (e.g., positive relationships, friendship, independence, self-confidence). However, these results also underline some points that require more attention and indicate future avenues of research. First, as for the previous clusters, outcome variables related to the outdoor environment have been often assessed through ad hoc measures: Further studies should address this point trying to validate more reliable instruments. This would also facilitate the comparison between different studies and results, thus providing a more systematic picture of the phenomenon. Second, research should try to integrate the investigation on indoor features with that on outdoor variables. Indeed, the relation between indoor and outdoor environments (hallways, windows, French window opening into the garden) has been barely explored. Furthermore, future studies should focus attention on individual differences that are likely to moderate such effects, as gender, age, and specific needs.

2. Discussion

From the review of the 68 papers selected according to specific criteria, a total of 68% of articles presented positive results, while the other ones showed negative results (29.2%), or no change (2.8%). Specifically, findings were organized in four sections based on exposure variables, i.e., architectural building design and aesthetic features, indoor environmental features, classroom design, and school green spaces or outdoor spaces.

About the first research question concerning the influence on users of *school building/architectural design/aesthetic features*, research has focused on the different impacts of new, old, and renovated buildings on students' performance. Findings showed that the better the building design, the higher the students' performance [8][18], as well as an increased positive benefit on students' wellbeing [12]. However, a negative effect on students' attention and sense of privacy was reported in the presence of flexible learning environments characterized by open and transparent designs (e.g., interior windows or open spaces [7]). Furthermore, regarding the adequate size of buildings, Slunjski [22] found that facilities should not be too large to foster the development of children's identities. According to this scholar, too many groups in a kindergarten make it difficult, or even impossible, for children to socialize and communicate with other children from the various groups, and such occurrence is also an obstacle to free movement of children throughout the facility. The learning space, indeed, becomes part of students' identity and, in turn, they become part of the place [23].

As for the second research question, about the association between the *indoor environmental features* of the school place and users' psychological responses, research outcomes illustrated the importance of features such as noise, ventilation, and lighting in enhancing the students' academic performance. Many of the studies have focused on the acoustic features, which are identified as a potential factor able to decrease attention and concentration. Specifically, school buildings close to main roads had a higher level of noise pollution, with a significant impact on students' and teachers' performance and comfort [13][24], impairing memory and learning [25], even though the extent of annoyance depends on the task (e.g., verbal tasks, and basic mathematics; [21][26]). Moreover, higher noise levels impeded the development of interaction and collaborative learning [27]. However, students' learning and concentration are also affected by lighting [28][29], and specifically natural light in classrooms was associated with both better health and better performance [30]. Finally, further factors showing a positive effect on short-term concentration and performance (e.g., logical thinking) are thermal comfort and ventilation [3][4].

As regards the third research question, about the effect on users of *classroom design/furniture*, research literature has showed the relevant role of the educational environment on students' performance and learning capacity. Furthermore, a classroom design with a flexible space promotes self-direct student learning [31][32] and teachers reported several benefits on students (i.e., increasing engagement with the addressed topics, retaining information, and increasing ability to learn and remember material [33]). Furniture (e.g., chairs) designed for children were also identified as features with a considerable impact [31]. Satisfaction, wellbeing, and comfort are triggered by ergonomic furniture painted with attractive colors and pictures [14], a well-equipped library, and a fitted blackboard [15].

Finally, about the fourth research question concerning the influence on users of *school green spaces/outdoor spaces*, studies have mainly focused on teachers' perceptions and students' learning in the outdoor learning experience. Indeed, school green spaces showed positive effects on students, both in terms of better health and higher engagement in lessons, improving critical thinking skills, problem-solving abilities, and enhancing sense of independence, motivation, and responsibility [5][34][35][36]. Outdoor lessons triggered students' desire to learn in a natural environment [37], also promoting children's imaginative play and the development of social positive relationships [38][39][40]. Furthermore, outdoor experience enhanced students' emotional responses [41]. According to Dhanapal and Lim [42], an integration of both indoor and outdoor learning is recommended in order to improve students' performance. Regarding teachers' perceptions, they positively underlined the impact of outdoor teaching, reporting a whole involvement of students' senses and resulting in an enhancement of students' learning [43][44]. Better social and personal wellbeing were also reported [45].

This analysis of the recent literature concerning the influence of design dimensions on school users' responses underlined a series of gaps and some inconsistencies that merit attention and are likely to open future avenues of research. One gap concerns the methodological domain. In fact, findings of this systematic review let emerge that quantitative research is poorly represented in two of the four clusters, i.e., *classroom design/furniture* and *school green spaces/outdoor spaces* (see also Table 1). Thus, there is a need for more quantitative evidence about the relationship between indoor/outdoor school settings and users' responses. The integration of qualitative and quantitative approaches and the use of more recent methodologies (e.g., based on virtual reality) could represent an added value for better understanding such relationships.

These new technologies, the integration of qualitative and quantitative methodologies, and of implicit and explicit measures could also be used to update the analyses of some processes and the impact of variables that have been widely explored in the past (e.g., the role of indoor environmental features such as noise, light, color) but narrowly analyzed in the decade considered in the present review. This might create a gap between the engineering, architecture, design advances, and our knowledge of the influences of such innovations on the users.

Future research should also focus on patterns that have been scarcely considered by prior studies. For instance, future research might explore how spatial features affect perceived control over the learning environment space on students' ability to have better control of their environment.

Finally, the present review also highlighted some inconsistencies detailed in previous sections. For instance, results related to school renovation or about the impact of noise on math performance are not clear-cut. These ambiguities might suggest the role of crucial moderator variables, such as interpersonal distance, compliance to social norms, and place identity, just to name a few. Thus, future research is called to explore the boundary conditions of such results and clarify better the mechanisms underlying the effects (see Figure 2).

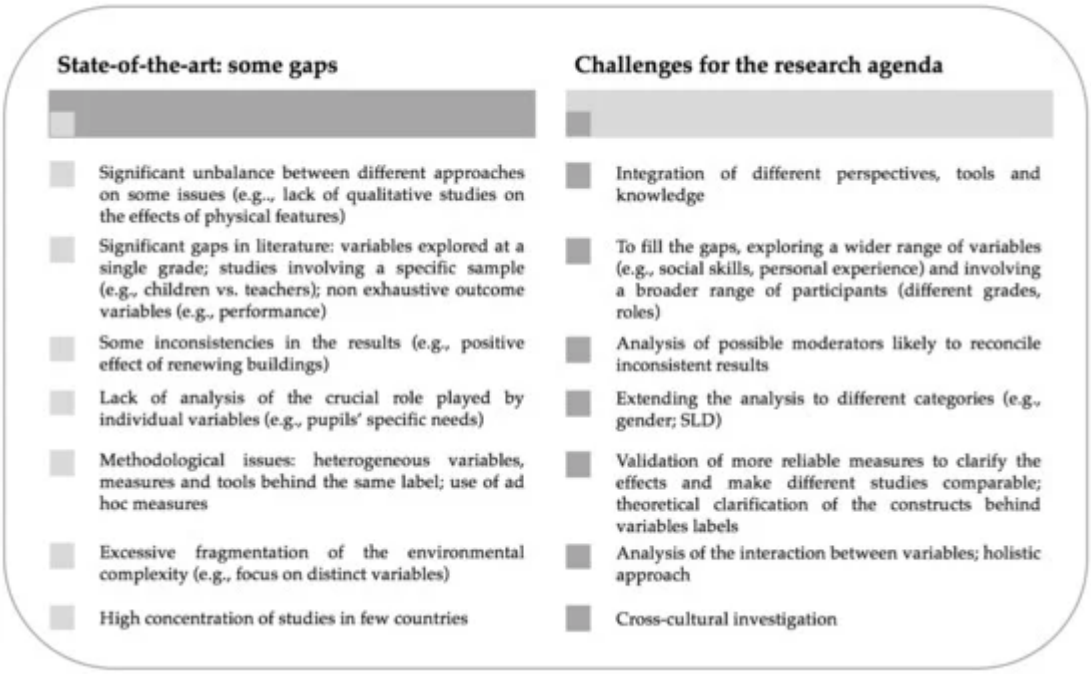

Figure 2. Summary of research gaps and challenges.

References

1. Judi Kidger; Ricardo Araya; Jenny Donovan; David Gunnell; The Effect of the School Environment on the Emotional Health of Adolescents: A Systematic Review. *Pediatrics* **2012**, *129*, 925-949, 10.1542/peds.2011-2248.
2. H. I. Castellucci; Pedro Arezes; Johan Molenbroek; R. De Bruin; C. Viviani; The influence of school furniture on students' performance and physical responses: results of a systematic review. *Ergonomics* **2017**, *60*, 93-110, 10.1080/00140139.2016.1170889.
3. Mendell, M.J.; Eliseeva, E.A.; Davies, M.M.; Lobscheid, A. Do classroom ventilation rates in California elementary schools influence standardized test scores? Results from a prospective study. Indoor Air 2016, 26, 546–557.
4. S. Petersen; K. L. Jensen; A. L. S. Pedersen; H. S. Rasmussen; The effect of increased classroom ventilation rate indicated by reduced CO 2 concentration on the performance of schoolwork by children. *Indoor Air* **2016**, *26*, 366-379, 10.1111/ina.12210.
5. Borić, E.; Škugor, A. Achieving Students' Competencies Through Research-Based Outdoor Science Teaching. Croat. J. Educ. 2014, 16, 149–164.
6. Moya Kinnealey; B. Pfeiffer; J. Miller; C. Roan; R. Shoener; M. L. Ellner; Effect of Classroom Modification on Attention and Engagement of Students With Autism or Dyspraxia. *American Journal of Occupational Therapy* **2012**, *66*, 511-519, 10.5014/ajot.2012.004010.

7. Roine Leiringer; Paula Cardellino; Schools for the twenty-first century: school design and educational transformation. *British Educational Research Journal* **2011**, *37*, 915-934, 10.1080/01411926.2010.508512.
8. Mozhgan Alsadat Ghaffarzadeh Hassankiade; A Comparative Study of Discrimination in Education: The Learning Environment and Behaviours of Students and Teachers in Iran. *IAFOR Journal of Education* **2016**, *4*, 34–46, 10.22492/ije.4.2.02.
9. Kiri T. Mealings; Katherine DeMuth; Jörg Buchholz; Harvey Dillon; Joerg Buchholz; The Development of the Mealings, Demuth, Dillon, and Buchholz Classroom Speech Perception Test. *Journal of Speech, Language, and Hearing Research* **2015**, *58*, 1350-1362, 10.1044/2015_jslhr-h-14-0332.
10. Punnoose, M.M.; Arya, R.; Nandurkar, A.N. Speech Perception in Noise among Children with Learning Disabilities. Int. J. Community Health Med Res. 2017, 3, 24–31.
11. Waters, J.; Maynard, T. What's so interesting outside? A study of child-initiated interaction with teachers in the natural outdoor environment. Eur. Early Child. Educ. Res. J. 2010, 18, 473–483.
12. Cuyvers, K.; De Weerd, G.; Dupont, S.; Mols, S.; Nuytten, C. Well-Being at School: Does Infrastructure Matter? CELE Exchange, No 2011/10; OECD Publishing: Antwerp, Belgium, 2011; Available online: https://EconPapers.repec.org/RePEc:oec:eduaac:2011/10-en (accessed on 26 January 2020).
13. Akhtar, J.; Anjum, N.; Iftikhar, N. Evaluation of the impact of noise pollution on students in congested area of Rawalpindi. Nurture 2013, 7, 1–9.
14. Maheshwar; Jawalkar, C.S. Ergonomic Based Design and Survey of Elementary School Furniture. J. Sch. Educ. Technol. 2014, 9, 27–31.
15. Martins, L.B.; Gaudiot, D.M. The deaf and the classroom design: A contribution of the built environmental ergonomics for the accessibility. Work 2012, 41, 3663–3668.
16. Karen M.K. Chan; Chi Mei Li; Estella P.-M. Ma; Edwin M.L. Yiu; Bradley McPherson; Noise levels in an urban Asian school environment. *Noise and Health* **2015**, *17*, 48-55, 10.4103/1463-1741.149580.
17. M. Gonçalves; Pedro Arezes; Postural assessment of school children: an input for the design of furniture. *Work* **2012**, *41*, 876-880, 10.3233/wor-2012-0257-876.
18. Lumpkin, R.B; School Buildings, Socioeconomic Status, Race, and Student Achievement. *J. Intercult. Discip.* **2016**, *15*, 170–185.
19. Porteous, D. Approaches to environmental aesthetics. J. Environ. Psychol. 1982, 2, 53–66.
20. Huebner, G.M.; Shipworth, D.T.; Gauthier, S.; Witzel, C.; Raynham, P.; Chan, W. Saving energy with light? Experimental studies assessing the impact of colour temperature on thermal comfort.

Energy Res. Soc. Sci. 2016, 15, 45–57.

21. Brännström, K.J.; Johansson, E.; Vigertsson, D.; Morris, D.J.; Sahlén, B.; Lyberg-Åhlander, V. How Children Perceive the Acoustic Environment of Their School. Noise Health 2017, 19, 84–94.
22. Aturupane, H.; Glewwe, P.; Wisniewski, S. The impact of school quality, socio-economic factors and child health on students academic performance: Evidence from Sri Lankan primary schools (English). Educ. Econ. 2013, 21, 2–37.
23. Fornara, F.; Andrade, C. Healthcare environments. In The Oxford Handbook of Environmental and Conservation Psychology; Clayton, S., Ed.; Oxford University Press: New York, NY, USA, 2012; pp. 295–315.
24. Bonnes, M.; Secchiaroli, G. Environmental Psychology. A Psycho-Social Introduction; Sage: London, UK, 1995.
25. Bronfenbrenner, U. The Ecology of Human Development: Experiments by Nature and Design; Harvard University Press: Cambridge, MA, USA, 1979.
26. Ljung, R.; Sörqvist, P.; Hygge, S. Effects of road traffic noise and irrelevant speech on children's reading and mathematical performance. Noise Health 2009, 11, 194–198.
27. McKellin, W.H.; Shahin, K.; Hodgson, M.; Jamieson, J.; Pichora-Fuller, M.K. Noisy zones of proximal development: Conversation in noisy classrooms. J. Socioling. 2011, 15, 65–93.
28. Hwa-Soo Lee; Sook-Youn Kwon; Jae-Hyun Lim; A Development of a Lighting Control System Based on Context-Awareness for the Improvement of Learning Efficiency in Classroom. *Wireless Personal Communications* **2015**, *86*, 165-181, 10.1007/s11277-015-2811-6.
29. Peter J. C. Sleegers; Nienke Moolenaar; M Galetzka; A Pruyn; Be Sarroukh; B Van Der Zande; Lighting affects students' concentration positively: Findings from three Dutch studies. *Lighting Research & Technology* **2012**, *45*, 159-175, 10.1177/1477153512446099.
30. Nilforoushan, M.; Hanna, R.; Naeini, H.S.; Mozzafar, F. Role and architectural characteristics in primary schools for day light in Glasgow (Scotland). Rev. High. Educ. Self-Learn. 2013, 6, 57–66.
31. Thomas J. Smith; Designing learning environments to promote student learning: Ergonomics in all but name. *Work* **2013**, *4*, 39-60, 10.3233/wor-121493.
32. Parnell, R.; Procter, L. Flexibility and placemaking for autonomy in learning. Educ. Child Psychol. 2011, 28, 77–88.
33. Benes, S.; Finn, K.E.; Sullivan, E.C.; Yan, Z. Teachers' Perceptions of Using Movement in the Classroom. Phys. Educ. 2016, 73, 110–135.
34. Yates, K.A.; Sullivan, S.C. Meaningful learning and school-based gardens: A multi-case study conducted in the harsh climate of the greater Yellowstone ecosystem. J. Ethnogr. Qual. Res.

2017, 11, 305–319.

35. James, J.K.; Williams, T. School-Based Experiential Outdoor Education: A Neglected Necessity. J. Exp. Educ. 2017, 40, 58–71.
36. Darren Sharpe; Independent thinkers and learners: a critical evaluation of the 'Growing Together Schools Programme'. *Pastoral Care in Education* **2014**, *32*, 197-207, 10.1080/02643944.2014.940551.
37. Gomboc, K. Back to Nature: Exploring the Potential for Implementing the Norwegian Idea of Outdoor Days in the Slovenian School System. J. Elem. Educ. 2016, 9, 123–138.
38. Kellie Dowdell; Tonia Gray; Karen Malone; Nature and its Influence on Children's Outdoor Play. *Journal of Outdoor and Environmental Education* **2011**, *15*, 24-35, 10.1007/bf03400925.
39. Barbara Flom; Carol Johnson; Jodi Hubbard; David Reidt; The Natural School Counselor: Using Nature to Promote Mental Health in Schools. *Journal of Creativity in Mental Health* **2011**, *6*, 118-131, 10.1080/15401383.2011.579869.
40. Beth Christie; Simon Beames; Peter Higgins; Context, culture and critical thinking: Scottish secondary school teachers' and pupils' experiences of outdoor learning. *British Educational Research Journal* **2015**, *42*, 417-437, 10.1002/berj.3213.
41. Hanvey, C.E. Experiences with an Outdoor Prop Box: Addressing Standards during Recess. Young Child. 2010, 65, 30–33.
42. Dhanapal, S.; Lim, C.C.Y. A comparative study of the impacts and students' perceptions of indoor and outdoor learning in the science classroom. In Asia-Pacific Forum on Science Learning and Teaching; The Education University of Hong Kong: Pok Fu Lam, Hong Kong, China, 2013; Volume 14, pp. 1–23.
43. Gehris, J.S.; Gooze, R.A.; Whitaker, R.C. Teachers' perceptions about children's movement and learning in early childhood education programmes. Child: CareHealth Dev. 2015, 41, 122–131.
44. Feille, K. Getting outside: Three teachers' stories of using the schoolyard as an integrated tool for elementary teaching. Electron. J. Sci. Educ. 2013, 17, n3. Available online: http://ejse.southwestern.edu/article/view/11643 (accessed on 26 January 2020).
45. Bortolotti, A.; Crudeli, F.; Ritscher, P. Outdoor learning in-service training for teachers. A case study from Prato. J. Plus Educ. Spec. Issue 2014, 2014, 61–68.