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ORIGINAL PAPER

Towards smart learning spaces in Catalan schools: teachers' perceptions of change

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Abstract
Moving towards Smart Learning Spaces (SLS) requires reconsideration of the school environment using a multi-dimensional approach that considers pedagogical, environmental and technological aspects. However, learning spaces have not changed that much. New designs and remodelling of educational contexts rarely are evidence-based and rarely incorporate teachers' insights, knowledge and perceptions of environments in which learning occurs. This paper explores the perceptions of and attitudes towards change of teachers working in preschool, primary and compulsory secondary education in Catalonia regarding SLS. To achieve this, a survey was carried out with 847 students. After checking the instrument's validity and reliability, univariate and bivariate analysis were followed by two-step cluster analysis. Teachers had a limited perception of their classrooms' actual suitability as SLS, which impedes further pedagogical reflection about change. Irrespective of actual classrooms conditions, three groups of teachers with different degrees of favourableness towards SLS were identified. These profiles bring to light contradictory perceptions regarding both constructivist, student-centred pedagogical assemblages involving environmental changes and certain conceptions and control practices that are more typical of traditional teaching styles. Recommendations can inform the decision-making of management teams and teachers about re-conceptualizing the learning space and their interventions in schools.

Keywords Classroom design · School innovation · Smart learning spaces · Teachers' perceptions

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Introduction

The competency and learning needs of twenty-first-century schoolchildren are not only forcing a reconsideration of teaching practices or the inclusion of digital resources (Chen et al., 2013), but also raising the need for changes in learning spaces in general (Bautista et al., 2019). This is because the space (natural and built environments) shapes social relations and practices (Massey, 1994), while socio-educational practices, teacher roles and social interactions shape the nature, use and experience of the space (Oblinger, 2006). However, despite evidence that changes in the environmental conditions of classrooms have a positive effect on the learning experience and its outcomes (Barrett et al., 2015b; Blackmore et al., 2011; Byers, 2016; Cleveland & Fisher, 2014; Richardson & Mishra, 2018), modern learning spaces have not changed much, at least as far as mainstream education is concerned. As modern as it might look from the outside, the classroom itself is still a highly-controlled space, often based on the teacher as a transmitter of knowledge, with students having a more-passive role, as opposed to a social environment that demands autonomy, flexibility, ability and creativity from students to make decisions and connect knowledge by themselves and through teamwork (OECD, 2011, 2017).

To date, the tendency when re-conceptualizing educational spaces is to modernize and integrate digital elements, while almost reproducing models similar to the traditional arrangement of rows of tables and chairs or tables in small groups (Byers & Imms, 2016). The usual process has involved new designs and the remodelling of educational spaces from an architectural viewpoint (Wells, 2015), generally without teacher input or evidence-based insights. These designs are usually based on a one-way pedagogical conception focused on the teacher (Nair & Fielding, 2005). In contrast, much of the research links improvement of the learning experience with classroom innovation through what are known as Innovative Learning Environments (ILE) (Charteris et al., 2017), New Generation Learning Spaces (NGLS) (Byers et al., 2018) or Smart Learning Spaces (SLS) (Bautista & Borges, 2013; Bautista et al., 2019). Typically, they are all classified as flexible formal or informal learning spaces shaped by their context and influenced by psychological, sociocultural and pedagogical stimuli. They encourage a range of teacher practices and open up real opportunities for students to develop the skills required for an increasingly complex world (Mahat et al., 2018). Although much of the literature associates the term 'smart' merely with the daily use of technology in schools, SLS go beyond this idea to allow the creation of a context-aware ecosystem that offers students instantaneous and adaptable support.

Thus, moving towards SLS means not only changing the environment or physical layout, but also considering spatial aspects alongside pedagogical and technological aspects (Baeta & Pedro, 2018) which could contribute to building a more-holistic understanding of learning environments. Many studies have already highlighted the importance of using a three-dimensional approach—pedagogical, environmental and digital (Bautista & Borges, 2013)—in the analysis and design of educational spaces (Ayre et al., 2014; Bannister, 2017; Barrett et al., 2015b; Brown et al., 2017; Byers et al., 2018; OECD, 2017). The pedagogical dimension refers to analysing how the pedagogical paradigm that guides the didactic action should also guide decisions about the learning space (Charteris et al., 2017). The environmental dimension refers to how the environment affects the development of teaching and learning processes, and how this might lead to methodological changes and new forms of learning (Barrett et al., 2015b; Marchand et al., 2014). Finally, the digital dimension involves the integration of technologies into learning spaces to foster

competence-based learning and creative, social, open and ubiquitous teamwork (Byers & Imms, 2016).

Improvements in all or some of these dimensions demand a regular financial investment based on the idea that innovation is not a one-time event but a continuous process. Technology, for example, is too expensive to be a simple replacement of non-technological methods of learning (Zucker, 2008). Schools spend either little money on SLS innovation or there are important mismatches in funding addressed to innovation, even though they all need to adapt to a rapidly-changing world (Serdyukov, 2017). This might also be conditioned by the fact that charter and state schools are entitled to different funding, which affects their decision-making capacity (Kho et al., 2020). All this influences teachers' beliefs and attitudes, because a lack of resources is usually perceived as an institutional constraint and individual unwillingness to engage in teaching innovations (Voigt et al., 2018), whereas investment is likely to empower and enable innovation and positive change for all.

In a similar vein, this multi-dimensional approach requires that each space responds to the needs of its agents and the educational context in which it is framed (Woolner et al., 2012), because conventional culture concerning traditional school building strongly influences how teachers' professional identities and pedagogical beliefs are constructed (Berger & Lê Van, 2019). Most redesign processes are not accompanied by systematic pedagogical reflection, particularly by the school's teaching staff, on the changes required in the educational project. If the learning spaces are to respond to the needs of the different teaching methodologies put into practice, teachers must have the major say in decisions concerning their design (Sanoff, 1978). Thus, it is essential to find out what teachers know and gauge their perceptions about contexts in which learning occurs and which affect student achievement and attitudes.

A certain degree of conservatism about teaching practices that prevent the emergence of reflective teachers to make changes to their physical space and teaching methods (Woolner et al., 2012). Although conservatism might seem related to age and experience, some studies have identified a continued desire for new experiences and pedagogical innovation in positive older teachers, described as a way of avoiding disillusionment associated with routine (Meister & Ahrens, 2011). However, school spaces overall are still very traditional in terms of their organization (OECD, 2011, 2017) and, in most of the cases, a lack an evidence base prevents their improvement as learning spaces.

The quality of teaching outcomes—closely connected with the capacity to innovate—is usually directly related to the experience, while early career teachers have been claimed as an untapped reserve of skills and talent to innovate and induce changes (Watters & Diezmann, 2015). Therefore, when educational change occurs or is attempted, teachers do not all respond in the same way: gender, subject speciality, age or stage of career, for instance, affect how they respond (Hargreaves, 2005). An organizational culture of innovation, as well as prior involvement in innovative projects, also enhances and encourages sustainable development in education (Akomolafe, 2011). However, the overall response of teachers to the requirements for driving change in teaching practice appears to be insufficient, and their perspectives are not taken into account in school design (Casanova et al., 2018).

While there have been many empirical studies focusing directly on assessing the effect of making different changes to a space on well-being and certain cognitive processes, methodologies or learning outcomes (Barrett et al., 2015a, 2015b; Benade, 2017; Brown et al., 2017), very few studies have assessed teachers' general perceptions concerning the space in which they carry out their immediate teaching activity, especially in primary and secondary education (Mulcahya et al., 2015; Shapiro, 2001). Although fewer studies have

examined teachers' attitudes to change, Martin's (2002) research is worth highlighting because it identified three types of teacher attitude: teachers who did not recognize the role of the environment in teaching and learning and who were unlikely to make the change happen; teachers—usually child-centred teachers—who showed dissatisfaction with their classrooms but viewed themselves as victims and did not do anything to change them; and a few environmentally-aware teachers who understood the impact of space and were using it accordingly. Likewise, Phillipson et al. (2018) added that teachers felt that traditional classroom spaces constrain not only what it is possible, but also the imaginary (instructors' ability to conceive what is possible in the first place). Likewise, Imms et al.'s study (2017) indicated that learning spaces are not aligned with current practice (intended for didactic styles designed to meet the demands of a rapidly-changing society), and that schools with a higher prevalence of traditional spaces are associated with lower scores for teachers' state of mind and students' deep learning. This led us to carry out an exploratory analysis of the perceptions of teachers in Catalonia regarding the three dimensions described above and to focus our attention on the classroom and not on other spaces within the school.

As an exploratory study, we include a vast array of teachers and learning environments within the compulsory educational stages, together with the preschool level. Assuming that there are differences between the educational stages, with the design of preschool and primary education learning spaces usually being more flexible, collaborative and personal, the differentiation of these educational stages creates administrative borders that are not likely to trigger innovation in terms of moving towards SLS differently. To the best of our knowledge, this study is one of the very few that addressed teachers' perceptions towards SLS, while complementing others that have focused more on the effect of changes in space on well-being, cognitive processes, methodologies or learning outcomes (Barrett et al., 2015a, 2015b; Benade, 2017; Brown et al., 2017). Moreover, following Hargreaves' (2005) claim that not all teachers respond in the same way, we explored variables such as age, educational experience, institutional resources, school ownership, education level, and previous innovation carried out by teachers.

Method

A survey, in the form of a quantitative and descriptive-explanatory questionnaire (Wolf et al., 2016), was used to gather the perceptions of teachers working within the compulsory educational stages (primary and compulsory secondary education) in Catalonia, but also in preschool education which is attached to primary schools in Catalonia. We analysed classrooms as SLS and specifically addressed the following research question: What are the perceptions of and attitudes towards change of teachers working in preschool, primary and compulsory secondary education in Catalonia regarding SLS? This question involves the following objectives:

- Identify, in terms of SLS, the current state of the classrooms in which teachers teach.
- Ascertain teachers' perceptions of classrooms as SLS, taking into account pedagogical, environmental and technological dimensions.
- Explore the relationship between teachers' perceptions and socio-demographic and contextual variables.
- Identify teacher profiles that are open to improvement based on perceptions.

The Autonomous Community of Catalonia, in the north-east of Spain, was chosen because it is responsible for setting its own public education policy. Catalonia is also where the largest number of schools are undertaking processes of change (Martínez-Celorrio, 2016).

Data collection

To ascertain teachers' perceptions of the classrooms as SLS, three 5-point Likert scales were designed (with 5 representing strongly agree and 1 representing strongly disagree) to measure the previously-defined three-dimensional approach: environmental, pedagogical and digital (Bautista et al., 2019). The scales were based on the design principles proposed by Oblinger (2006), Barrett et al. (2015b) and Bautista and Borges (2013). The environmental scale contained 9 items assessing the importance attributed by teachers to the classroom's space in general (i.e. organizational aspects, presence of elements and the classroom's general design) and for learning in particular (i.e. the classrooms must have differentiated spaces to read, rest, design, research, etc.). The pedagogical scale comprised 9 items to identify the relationship perceived by teachers between the classroom's physical space and the teaching methodologies and dynamics (i.e. it is important that students are able to move freely around the classroom). Finally, the technological scale contained 9 items about the importance attributed by teachers to the integration of technologies into the classroom (i.e. it is necessary to integrate tablets, mobile telephones, etc. into the classroom). The scales demonstrated content and construct validity and good reliability (Table 1). For the three scales, the KMO test showed statistical significance and adequacy (Environmental Scale: $\chi^2_{(36)} = 1612.04$,

Table 1 Data-gathering instrument

Dimensions and variables	Measurement scale
Socio-demographic and contextual data	
Teacher's gender	Categorical dichotomous
Age	Scalar
Years of teaching experience	Categorical
Education level at which most teaching is delivered	Categorical
Ownership of the school at which the classes are given	Categorical dichotomous
School's geographical location	Categorical
Capacity to change the classroom layout	Categorical dichotomous
Availability of financial resources at the school to make changes in the spatial layout	Categorical dichotomous
Have taken part in innovation projects	Categorical dichotomous
Classroom reality scale (10 items)	
Environmental dimension Pedagogical dimension Technological dimension	Scalar (1 to 5) $\alpha = 0.6$
Classroom perception scale (27 items)	
Environmental aspects perception scale (9 items) Pedagogical aspects perception scale (9 items) Technological aspects perception scale (9 items)	Scalar (1 to 5) $\alpha = 0.76$ Scalar (1 to 5) $\alpha = 0.87$ Scalar (1 to 5) $\alpha = 0.7$

$p = 0.000$, KMO = 0.82; Pedagogical Scale: $\chi^2_{(36)} = 2745.07$, $p = 0.000$, KMO = 0.91; Technological Scale: $\chi^2_{(36)} = 1661.55$, $p = 0.000$, KMO = 0.75). Bautista et al. (2019) detailed the dimensionality of each scale, as well as factor loadings, which were above 0.4 for all items.

To identify the current state of classrooms in Catalonia, a 10-item scale was designed to assess the same three dimensions. The environmental dimension comprised 3 items, the minimum number considered acceptable for a scale (Frias-Navarro, 2019). (That is, the classrooms in which I teach have a traditional organization and structure: rows of desks and chairs with the teacher's desk and blackboard at the front.) The pedagogical dimension had 3 items. (That is, the classrooms in which I teach facilitate the development of learning formats that encourage cooperation.) The technological dimension contained 4 items. (That is, I integrate the use of mobile technologies—tablets, mobile phones, etc.—into the activities I plan.) This scale has a moderate reliability (0.6), which is considered acceptable for initial or exploratory studies (Nunnally & Bernstein, 1994) or satisfactory for scales with less than 10 items (Loewenthal, 1996). Also, the Bartlett's sphericity index and KMO test showed significance and adequacy ($\chi^2_{(45)} = 1843.49$, $p = 0.000$, KMO = 0.73). The analysis showed a structure of three factors that explained 58% of the variance and which correspond to the factors in the scale. Item loadings were greater than 0.5.

In addition, other basic demographic and contextual variables were requested (Table 1): age, gender, years of teaching experience, educational level at which the classes are given, ownership of the teachers' school, the school's location, interest in teaching innovation (measured by participation in innovation projects), ability to change classroom layouts, and availability of funds at the school to make changes to the space.

Participants

The study involved 847 teachers affiliated with the different territorial educational departments in all four Catalan provinces. They were selected through multi-stage sampling: at first, centres in Catalonia were randomly selected; and, secondly, teachers were taken from each centre selected by convenience. The sample was obtained from the 10 educational departments of Catalonia. The selection was four centres per department (preschool and primary schools and two compulsory secondary education schools). In total, there were 40 schools. The number of teachers' responses varied between schools because they answered voluntarily. In compulsory secondary education, 342 teachers answered whereas, in preschool and primary schools, there were 505 teachers who answered (137 in preschool and 368 in primary education). Teachers answered the questionnaire between May and September 2017. Consent was requested in advance as required by the Universitat Oberta de Catalunya's Research Ethics Committee.

The participating teachers' mean age was 43.63 years; 80% were women and 20% were men, reflecting the sector's female–male split. Most teachers had more than 10 years of teaching experience (74.7%), 12% had between 6 and 10 years of experience, and 13% had less than that. A total of 83.4% had worked in state schools, 14% in charter schools, and only 1.2% in private schools. The majority (79.4%) thought that they could change the layout of their classrooms; and 46.3% said that their school had the funds to do so, whereas 38% thought the school did not, and 16% did not know. Lastly, 49% of teachers had taken part in teaching innovation projects.

Data analysis

Prior to conducting the analysis, we first verified the instrument's reliability and validity using two methods. For this exploratory study, we conducted several analyses to identify the one that yielded the most-satisfactory results for interpretation. A principal component analysis (PCA) was chosen in order to identify the underlying variables. In all the scales, the KMO test showed significance and adequacy ($p = 0.000$ and KMO > 0.5). We adopted a factor loading criterion of 0.32 for inclusion of an item in the interpretation, which is consistent with Comrey and Lee (1992) who suggested that the criterion should be set a little higher than 0.32. A reliability analysis was also carried out for the internal consistency of the scales using Cronbach's alpha coefficient. Details have been published in Bautista et al. (2019). Pearson correlations between the three scales (and high between the environmental and pedagogical scales) were significant. The central tendency indexes and proportions are given for the descriptive analysis of the results. Comparisons of means with parametric tests are given because they have greater statistical power. Authors such as Winter and Dodou (2010) or the Minitab Statistics platform (2016) state that mean contrast analyses with five-point Likert scales and large samples (with a minimum of 10 per group) can assume both parametric and non-parametric tests; the advantage of the former is their greater statistical power, with a greater probability of detecting a significant effect when one actually exists. In addition, *t*-tests with large samples are resistant to deviations from normality. The second method of analysis involved segmenting teachers. The two-step cluster technique was used to discover natural groupings in a dataset and identify possible teacher profiles. The two-step clustering algorithm is based on a distance measure that gives the best results if mixed-type variables (categorical and continuous) are used. All the above operations were carried out using the IBM SPSS Statistics (v.25) software.

Results

Reality of classrooms in which teachers teach

Regarding the first specific objective, there were low to moderate scores for the classrooms' actual suitability to act as integral learning spaces (Table 2). With the lowest mean score, technology appears not to be integrated into the classrooms ($M = 2.73$), especially mobile technology and robotics. In terms of the environmental dimension, layouts have a somewhat traditional organization and contain aspects that have a negative impact on students ($M = 3.36$). The pedagogical dimension scores highest, indicating a moderate capacity for implementing diverse learning methodologies ($M = 3.4$).

Table 2 Scores for classroom environmental, pedagogical and technological dimensions

Dimension	*N*	Minimum	Maximum	Mean	SD
Environmental	841	1.67	5.00	3.36	.70
Pedagogical	839	1.00	5.00	3.40	.93
Technological	821	1.00	5.00	2.73	.84
Total	807	1.50	4.90	3.11	.55
Valid *N* (by list)	807				

When the school's ownership is considered (Table 3), the environmental and technological dimensions show significant differences ($p=0.017$ and $p=0.000$, respectively). In both cases, the charter centres score higher, perhaps because they have less-traditional layouts and a higher integration of technology than in state school classrooms.

When educational level is considered (Table 3), the differences are significant within each dimension ($p=0.000$ for all cases). Compulsory secondary education has the most-traditional conditions, with more-traditional layouts and less capacity for implementing different methodologies. However, this is the educational level with the greatest presence of technology, followed by primary and preschool education.

Perception of classrooms as SLS

Regarding the second specific objective, the highest scores were for the pedagogical ($M=4.14$) and environmental scales ($M=4.02$) (Table 4). Thus, the teachers have a strong perception of the classroom's space as such (layout, environmental conditions, conditions that allow the integration of all students) and the link to pedagogical aspects (differentiation of spaces, flexibility for using different learning methodologies, students' inclusion and freedom of movement, and their motivation through the existence of spaces better suited to their development). However, they have a weaker perception of the importance of integrating technology ($M=3.52$), including fixed elements (computers, digital blackboards, etc.), mobile elements (tablets and smartphones) and robotics.

These results change when the socio-demographic and contextual variables are taken into consideration (Table 5). Regarding age, significant differences are observed for the pedagogical and technological scales ($p=0.048$ and $p=0.039$, respectively); younger teachers had more-positive perceptions (Bonferroni, $p=0.047$) of the pedagogical aspects and teachers aged 36–50 years had more-positive perceptions of the technological aspects.

With regards to the contextual variables, the educational level is a sensitive variable for all three scales ($p=0.000$). For the environmental scale, the strongest perceptions are in preschool education, followed by primary and compulsory secondary education. There are no significant differences in the pedagogical scale between preschool and primary education, but there are between these two levels and compulsory secondary education (Bonferroni, $p=0.000$); compulsory secondary education has the weakest perception of the pedagogical aspects. In the case of the technological scale, the differences are to be found above all between preschool and compulsory secondary education (Bonferroni, $p=0.000$), and the latter has the strongest perception of the integration of technology. Ownership of the school also correlates with the pedagogical and technological scales ($p=0.045$ and $p=0.001$, respectively); in both cases, the teachers working in charter schools show a more-favourable attitude towards these aspects.

Furthermore, teachers show more-favourable perceptions for all scales when they have been involved in innovation projects ($p=0.000$ in all cases). However, the availability of funds at the school for changing the spatial layout influences teachers' perceptions only with respect to the environmental scale ($p=0.029$); teachers in schools with funds have a more-positive perception of the environment.

Teacher profiles regarding SLS

The 847 respondents were classified into three teaching profiles. The allocation to the groups was made using a two-step cluster, using an algorithm involving four variables

Table 3 Classroom reality testing statistics and contextual variables

Contextual variable	Environmental dimension			Pedagogical dimension			Technological dimension			Total		
	Mean	*t/F*	*p*	Mean	*t/F*	*p*	Mean	*t/F*	*p*	Mean	*t/F*	*p*
School ownership												
State	3.33	$t=-2.40$	.017	3.37	$t=-1.47$	.143	2.69	$t=-3.56$	.000	3.08	$t=-3.81$	.000
Charter	3.51			3.51			2.98			3.30		
Education level												
Preschool	3.76	$F=80.52$	.000	3.77	$F=29.24$	.000	2.28	$F=87.26$	.000	3.16	$F=.794$	.452
Primary	3.52			3.50			2.49			3.09		
Secondary	3.03			3.13			3.14			3.10		

Table 4 Scores for the perception scales

Scale	*N*	Minimum	Maximum	Mean	SD
Environmental scale	836	1.56	5.00	4.0198	.60766
Pedagogical scale	826	1.33	5.00	4.1394	.67630
Technological scale	794	1.44	5.00	3.5278	.55167
Valid *N* (by list)	767				

Table 5 Relationship between teachers' perceptions and socio-demographic and contextual variables

	Environmental scale			Pedagogical scale			Technological scale		
	Mean	*F/t*	*p*	Mean	*F/t*	*p*	Mean	*F/t*	*p*
Age									
< 35	4.10	$F = 2.60$	.075	4.25	$F = 3.04$	.048	3.46	$F = 3.25$	.039
35–50	4.03			4.14			3.58		
> 50	3.95			4.08			3.50		
Availability of financial resources at the school to make changes to the spatial layout									
Yes	4.09	$t = -2.18$	.029	4.20	$t = -1.32$	.187	3.55	$t = -428$	.668
No	3.99			4.13			3.53		
Education level									
Preschool	4.35	$F = 71.37$	.000	4.39	$F = 62.81$	.000	3.36	$F = 8.43$	.000
Primary	4.14			4.32			3.51		
Secondary	3.74			3.83			3.60		
Ownership of the school									
State	4.01	$t = -660$	.510	4.11	$t = -2.01$	.045	3.49	$t = -3.38$	.001
Charter	4.04			4.23			3.69		
Have taken part in innovation projects									
Yes	4.12	$t = -4.66$	.000	4.23	$t = -3.76$	.000	3.61	$t = -4.44$	.000

(environmental scale; pedagogical scale; technological scale; and individual ability to implement changes in the classroom). This algorithm shows three clusters with a good-quality index (Profile Cohesion Mean higher than 0.5). Three different teacher profiles emerged with respect to their perceptions of classrooms as SLS and their openness to change.

Cluster 1 (ability, strong perception of change) is the largest group, comprising 57.7% ($n = 437$) of the sample. On their own, this group is able to implement changes in their classrooms' layouts and show the best perception of the learning spaces' dimensions (environmental, pedagogical and technological). This group consists mainly of primary and preschool teachers, with more teaching experience (over 10 years), who are middle-aged ($M = 43$ years), have undertaken pedagogical innovations, and have access to funds to make changes in the school space. With respect to the reality of their classrooms, their scores are the highest for the environmental and pedagogical scales (and they therefore have less-traditional classrooms and use different teaching methodologies). This teacher group shares,

to a high degree, the opinion that the classroom's structural, pedagogical and technological design is important for facilitating change.

Cluster 2 (ability, weak perception of change) comprises 22.5% ($n=170$) of participants. These teachers can implement changes but have a weaker perception in all the learning spaces' dimensions. This group consists mainly of compulsory secondary-school teachers, with teaching experience, but who are older (making up the oldest group with a mean age of 46 years), have not participated in many innovation projects, and know their schools could make changes to the space. They also say that their current classrooms' structural and pedagogical realities are aligned with their students' needs. They teach in somewhat more-traditional classrooms and with less capacity to implement diverse teaching methodologies. These teachers are less likely to believe that the classroom's structural, pedagogical and technological design is important for facilitating change.

Lastly, Cluster 3 (little ability, strong perception of change) comprises 19.8% of the sample ($n=150$). These teachers are unlikely, on their own, to be able to implement changes and have a strong perception on all the scales, but not as strong as the first group. This group consists of younger compulsory secondary- and primary-school teachers, with less teaching experience, who have not taken part in many innovation projects, and who know that their schools do not have the funds to implement changes. They say that their classrooms are traditional, and disagree that their current classrooms' reality is aligned environmentally with their students' learning needs. They are also less in favour of using different pedagogical formats. They moderately agree that the classroom's structural, pedagogical and technological design is necessary for facilitating change.

Table 6 summarizes the variables with statistically-significant differences between the three groups. Data are presented separately for qualitative and quantitative variables based on the statistical testing used. All variables show significant differences between the three profiles, except for the technological scale in the case of the reality of classrooms.

Discussion

With respect to the first specific objective, teachers tend to have a negative perception of their classrooms' actual suitability as SLS (Mulcahya et al., 2015). Although classrooms allow diverse teaching methodologies to be implemented, the possibilities could be much greater for transitioning from teacher-directed learning to more self-managed learning by the student, reducing drill times and increasing collaborative and investigative work. These ideas have been present for decades in the reform-oriented sector of the school system, such as Montessori and Helen Parkhurst's Dalton Plan schools (OECD, 2011). However, in mainstream settings, the classroom-based school has rarely been replaced or rethought as a socio-spatial assemblage (Dovey & Fisher, 2014). The greatest efforts have been made in the earlier educational stages (Cabanellas & Eslava, 2005). Our results show that, although compulsory secondary education has the greatest technological integration, the most-substantial changes in the environmental and pedagogical aspects have taken place in preschool education.

Our results also show that the best environmental and technological conditions are in charter schools. Perhaps this is because of their greater independence in obtaining and managing funds to address the redesign of their spaces. Meanwhile, governments continue to be responsible for creating the policy environment within which local authorities act

Table 6 Statistical significance of the variables in the three different teacher profiles

Quantitative variables	Mean			*F*	*p*
	Cluster 1	Cluster 2	Cluster 3		
Environmental scale (reality)	3.53	3.25	2.98	42.094	.000
Pedagogical scale (reality)	3.56	3.48	2.84	37.123	.000
Technological scale (reality)	2.75	2.75	2.72	.060	.942
Environmental scale (perception)	4.31	3.29	4.00	316.45	.000
Pedagogical scale (perception)	4.45	3.32	4.17	318.18	.000
Technological scale (perception)	3.67	3.10	3.56	79.19	.000
Qualitative variables	Cluster 1 (%)	Cluster 2 (%)	Cluster 3 (%)	Chi squared	*p*
Age				24.35	.000
Under 35	20.7	12.8	32.6		
35 to 50	58.4	53.8	45.7		
Over 50	20.9	33.3	21.7		
Teaching experience				40.74	.000
Under 3 years	4.6	2.4	16		
3 to 5 years	4.8	10.7	10		
6 to 10 years	12.4	10.1	12		
Over 10 years	78.2	76.9	62		
Educational level				71.48	.000
Preschool	21.6	8.2	8.7		
Primary	49.9	30.6	36.9		
Secondary	28.5	61.2	54.4		
Prior participation in innovation projects				14.55	.001
Yes	54	42.7	37.4		
No	46	57.3	62.6		
The school has funds to make changes to the spaces				42.39	.000
Yes	55.3	46.4	25.5		
No	33.4	35.7	50.3		
Don't know	11.3	17.9	24.3		

and, until now, they continue to focus primarily on learning outcomes and teacher training, without paying too much attention to the learning spaces (OECD, 2011).

Regarding the second objective, focused on ascertaining teachers' perceptions of their classrooms' possibilities, teachers are well aware of these issues. This is linked to the third objective related to the exploration of contextual and socio-demographic variables, aligned with authors such as Hargreaves (2005) who state that teachers do not all respond in the same way. Thus, the weakest perceptions were for the integration of technology (fixed, mobile or robotic), but older teachers are more open to considering it necessary within the classroom to create new learning environments. This finding is in line with Meister and Ahrens (2011), who suggest that being older is not necessarily linked to a more-negative attitude towards change. This might also be linked to previous studies which indicate that a greater degree of digital exposure to technology is not necessarily related to a greater

ability to use it in daily life (Guo et al., 2008). Younger teachers might be more critical about the real possibilities of integrating technology into the classrooms because of their higher exposure to it. In turn, our results have also shown that these younger teachers have a better perception of the pedagogical dimension.

As we have also seen with respect to teachers' perceptions of the reality of Catalan classrooms, those working in the earlier stages of education give most importance to all the dimensions of SLS. This confirms the importance of the teaching *habitus* of the school where preschool and primary school teachers teach with respect to pedagogies, spaces, training and career background. Likewise, as was also the case with this study's first objective, this trend is reversed when technological aspects are considered: compulsory secondary-school teachers have the strongest perception of their integration, while preschool teachers give the least importance to it. Perhaps, at this stage, learning inputs and resources are much more experiential and manipulative of reality, which means that use of technological resources is more sporadic and plays a less-important role in creating contexts in which learning occurs.

Prior participation in innovation projects also influences teachers' attitudes towards the effect of environmental, pedagogical and technological aspects on their students' learning, reinforcing the close relationship that exists between innovation and change in the teaching mindset, even when the evidence of improvement is not always systematized (Goodyear & Casey, 2013).

Having financial resources has a significant impact on the environmental scale, with teachers from schools with more resources showing a stronger perception of environmental aspects. This is an anticipated result because changes in spaces carry high costs, and teachers' perception can be negatively affected by their real possibilities (Serdyukov, 2017).

Along with this, school ownership also exerts an influence on the perception of the teaching staff, with teachers from state-owned centres showing the worst perception on the pedagogical and technological scales, but with no differences in the environmental scale (with favourable perceptions in the two groups). State schools are normally subject to reduced management agreements and financial endowments, which limit decision-making and the opportunity to innovate (Kho et al., 2020). In addition, these teachers also receive less extrinsic incentives for professional development than teachers in charter schools (Brown, 2009). Implementing pedagogical changes and the inclusion of ICT requires an effort that is not always readily accepted by state school teachers.

In relation to the fourth objective, regarding appraising teachers' attitudes towards change, three teacher groups were identified that show (a) a clearly-favourable perception of SLS (Cluster 1), (b) a favourable perception but to a lesser degree (Cluster 3), and (c) a neutral perception (Cluster 2). In all three cases, the element that defines the group is teachers' ability to implement changes in the school to create new learning environments, especially in the space with the greatest teaching load, namely, the classroom. The findings about teachers' perceptions in Catalonia are not surprising. Unlike the findings in Martin (2002), which showed very few environmentally-aware teachers, Catalan teachers show awareness of learning spaces irrespective of whether they have the opportunity to make changes in their immediate reality (Clusters 1 and 3). This could be explained by the calls for educational change because the school was not designed as a competency-based education system (UNESCO, 2015). Initiatives are also currently under way in Catalonia, such as the current *Xarxes per al canvi* programme led by the Barcelona City Council and the Government of Catalonia with a particular focus on innovative learning environments (OECD, 2015), are also impacting on teachers' perceptions and conceptions.

However, more-ambivalent teachers are a cause for concern. With weaker perceptions in all the dimensions analysed, they are less open to implementing changes. It is also surprising that all three groups have a weaker perception of the possibilities offered by technological integration in creating new forms of association and learning. This might be explained by the contradictions proposed by Dovey and Fisher (2014) between teachers' desire to implement constructivist, student-centred pedagogies and the transfer of control implied in rethinking and questioning more-traditional hierarchical structures (space and time organization, etc.). Rethinking learning spaces and facilitating change comes up against the power and resistance naturally emanated by the classroom-based schools. It is precisely in this power play that technologies have a leading role in questioning the scope of space and time. Moving towards a greater degree of technological integration is one of the elements that most seriously challenges resistance to change.

These results should be considered as indicators—sufficient and not always necessary—of teachers' perceptions, opinions and attitudes (Woolner et al., 2007). As an exploratory study, we decided to include a vast array of teachers and learning environments within the compulsory educational stages in Spain, which might be a limitation of the research because of the nature of learning activities taking place in each school setting. However, the current study is one of the few that report teachers' perceptions of the classrooms as SLS. To date, research centred on learning spaces and their effects on students has been carried out mainly in Western Europe and in English-speaking countries such as Australia or the United States. In Catalonia, this research is still highly necessary precisely because SLS vary between countries in ways that are related to understandings and philosophies of education, as well as to material resources (Alexander, 2000). Indeed, this is another of the limitations of the study: it is difficult to compare these results with other studies in the field.

Another limitation relates to the second part of the non-random sampling involving teachers. Although the sample has an adequate number of participants and distribution of teachers throughout the Catalan territory, all teachers answered voluntarily. These teachers who answered might be more motivated by the topic and, while motivation does not directly translate into their perceptions, we do not know the perceptions of those who did not answer. Future research can overcome these limitations. The results show a trend that needs to be confirmed in further studies. Likewise, in forthcoming applications of the questionnaire, the stability or variation of the reliability values should be further investigated, even though Nunnally and Bernstein (1994) suggest that reliability values of up to 0.6 can be acceptable for exploratory studies, and Loewenthal (1996) argues that reliability values of 0.4 can be accepted for scales with a maximum of 10 items. It also will be important to use predictive techniques to explore what factors can predict positive perceptions of change in teachers. But not only is the quantitative approach sufficient, it is also desirable to conduct studies with mixed or qualitative comprehensive approaches, which could help to nuance the results found in understanding the motives and meanings that teachers attribute to their perceptions.

Despite the exploratory nature of the study—and therefore the impossibility of drawing definitive conclusions—this study overall provides empirical evidence about the different degrees of favourableness towards SLS. One of the issues worth investigating is the contradictory resistance to change in the technological dimensions shown in the analysis. Further research is also needed to gather the opinions on SLS of those responsible for educational policies, as is research into the design of smart classrooms, their suitability for pedagogical change and teachers' perception of them.

In short, generalisation of the results requires caution. However, the study has helped to broaden the body of scientific knowledge on the subject, while also providing some insights into educational practice. In this sense, our recommendations can help to inform the decision-making of administrators, management teams and teachers in envisioning and conceptualizing learning environments, as well as their interventions in schools. Our findings are also addressed to educational policy leaders and funding and management teams.

A relationship between financial resources and a favourable perception of change is observed. Teachers whose schools have sufficient resources perceive to a greater extent the need to remodel the classroom space. The remodelling of the spaces carries high costs. Likewise, teachers of charter schools with a lower ratio of students and higher financial endowment have a better perception of the importance of introducing improvements into the pedagogical and technological aspects. The more that teachers participate in innovations, the better their perception of change will be. In this sense, we recommend that state schools allocate more resources for changes in the spaces and technological infrastructures as well as in innovation projects, in order to create a better balance in commitment towards change of teachers from different kinds of school ownership. Likewise, teaching teams must be trained in the need to implement these changes and make innovations. It is important to acknowledge that, while financial investments are necessary to avoid funding gaps among schools and to provide opportunities for change (Zucker, 2008), funds by themselves are not sufficient.

Finally, the educational level has proved to be a variable that reveals that the goal of most secondary-school teachers is far removed from changes and innovations. Future university entrance examinations at the end of secondary education have become the main goal of many centres, which restricts the possibility of pedagogical, environmental or technological improvement. Study-based teaching and examinations are a clear threat to these kinds of improvement. Teaching teams should promote a balance between providing students with high academic skills and improving teaching and innovation.

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