Towards Smart Learning Spaces in Catalan schools: teachers' perceptions of change

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 incorporate teachers' insights, knowledge and perceptions of environments in which learning occurs, nor are they evidence-based. 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 study was carried out (n = 847). After the verification of the instrument's validity and reliability, univariate and bivariate analysis were performed, followed by a two-step cluster analysis. The findings show that teachers have a weak perception of their classrooms' actual suitability as SLS, which impedes further pedagogical reflection about change. Irrespective of the classrooms' actual conditions, the analysis identified three groups of teachers with different degrees of favourability towards SLS. 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 in re-conceptualizing the learning space, as well as their interventions in schools.

Keywords

Classroom design, smart learning spaces, school innovation, teachers' perceptions

1. Introduction

The competency and learning needs of 21st-century schoolchildren are not only forcing a reconsideration of teaching practices or the inclusion of digital resources (Chen et al. 2013), but are also raising the need for changes in learning spaces in general ([Anonymised-author] 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 the evidence that changes in the environmental conditions of classrooms may have a positive effect on the learning experience and its outcomes (Barrett, Zhang, Davies, and Barrett 2015; Blackmore, Bateman, Loughlin, O'Mara, and Aranda 2011; Byers 2016; Cleveland and Fisher 2014; Richardson and Mishra 2018), modern learning spaces have not changed much, at least as far as mainstream education is concerned. As modern as it may 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 has been to modernize and integrate digital elements, while almost reproducing models similar to the traditional

arrangement of rows of tables and chairs or tables grouped in small groups (Byers and Imms 2016). The usual process has been for new designs and the remodelling of educational spaces to be approached from an architectural viewpoint (Wells 2015), generally without teacher input nor evidence-based insights. These designs are usually based on a one-way pedagogical conception focused on the teacher (Nair and 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, Smardon, and Nelson 2017), New Generation Learning Spaces (NGLS) (Byers, Mahat, Liu, Knock, and Imms 2018) or Smart Learning Spaces (SLS) ([Anonymised-author] 2013; 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, Bradbeer, Byers, and Imms 2018). Although much of the literature associates the term 'smart' merely with the daily use of technology in schools, SLS go beyond this idea and allow for the creation of a context-aware ecosystem that can offer students instantaneous and adaptable support.

Thus, moving towards SLS means more than just changing the environment or physical layout, and means considering spatial aspects alongside pedagogical and technological aspects (Baeta and 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 ([Anonymised-author] 2013)—in the analysis and design of educational spaces (Ayre et al. 2014; Bannister 2017; Barrett, Zhang, et al. 2015; 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 change and new forms of learning (Barrett, Zhang, et al. 2015; Marchand, Nardi, Reynolds, and Pamoukov 2014). Finally, the digital dimension analyses the integration of technologies into learning spaces to foster competence-based learning and creative, social, open, and ubiquitous teamwork (Byers and 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 process of continuous improvement. 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 effects their decision-making capacity (Kho, Zimmer, and Buddin 2020). All this influences teachers' beliefs and attitudes, since the lack of resources is usually perceived as an institutional constraint and individual unwillingness to engage in teaching innovations (Voigt, Hofer, and Schön 2018), whereas investment should empower and enable innovation and positive change for all.

In a similar vein, this multi-dimensional approach requires that each space respond to the needs of its agents and the educational context in which it is framed (Woolner et al. 2012), as conventional culture concerning traditional school building strongly influences how

teachers' professional identities and pedagogical beliefs are constructed (Berger and 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 biggest 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.

To this is added a certain degree of conservatism in some teaching practice that prevents the emergence of reflective teachers to make changes to their physical space and teaching methods (Woolner, McCarter, Wall, and Higgins 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 and Ahrens 2011). Be that as it may, school spaces overall are still very traditional in terms of their organization (OECD, 2011; 2017), and in most of the cases they are not evidence-based so that they can effectively improve learning spaces.

Besides, 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 and Diezmann 2015). Therefore, when educational change occurs or is attempted, teachers do not all respond in the same way: gender, subject speciality, age or their 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 perspective is not taken into account in school design (Casanova, Di Napoli, and Leijon 2018).

While there have been many empirical studies focusing directly on assessing the effect that making different changes to the space has on well-being and certain cognitive processes, methodologies or learning outcomes (Barrett, Barrett, and Zhang 2015; Benade 2017; Brown et al. 2017), very few studies assess teachers' general perceptions concerning the space in which they carry out their immediate teaching activity, especially in primary and secondary education (Mulcahya, Cleveland, and Aberton 2015; Shapiro 2001). Fewer still examine teachers' attitudes to change (Martin 2002). However, one study worth highlighting in this respect is that of Martin (2002) 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, Riel and Leger (2018) added that teachers felt that traditional classroom spaces constrain not only what it is possible to do, 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 has

led us to carry out an exploratory analysis of the perceptions of teachers in Catalonia regarding the three dimensions described above and to focus the study's 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 the 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 should not trigger innovation in terms of moving towards SLS differently. To the best of our knowledge, this study is one of the very few that addresses 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, Barrett, and Zhang 2015; Benade 2017; Brown et al. 2017). Moreover, following Hargreaves' (2005) claim that not all teachers respond in the same way, it explores variables such as age, educational experience, institutional resources, school ownership, education level, and previous innovation carried out by teachers.

2. Method

A survey, in the form of a quantitative and descriptive-explanatory questionnaire (Wolf, Joye, Smith, and Fu 2016), was used to analyse the perceptions of teachers working within the compulsory educational stages, thus primary and compulsory secondary education, in Catalonia, but also including preschool education which is attached to primary schools in Catalonia. It 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 teachers teach in.
- Ascertain teachers' perceptions of classrooms as SLS, taking into account the 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 the perceptions evidenced.

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 we find the largest number of schools undertaking processes of change (Martínez-Celorrio 2016).

2.1. Data collection

To ascertain teachers' perceptions of the classrooms as SLS, three 5-point Likert scales were designed (where 5 is strongly agree and 1 is strongly disagree) to measure the three-dimensional approach: environmental, pedagogical and digital, previously defined in [Anonymised-author] (2019). The scales were based on the design principles proposed by Oblinger (2006), Barret, Zhang, et al. (2015) and [Anonymised-author] (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 be able to move freely around the classroom). Finally, the technological scale contained 9 items on the importance attributed by teachers to the integration of technologies into the classroom (i.e. it is necessary to integrate tablets, mobile phones, etc. into the classroom). The scales demonstrated content and construct validity, and a good and acceptable reliability (Table 1). In the three scales, the KMO test showed significance and adequacy (Environmental Scale: $\chi^2_{(36)} = 1612.04$; $p = .000$ and KMO = 0.82; Pedagogical Scale: $\chi^2_{(36)} = 2745.07$; $p = .000$ and KMO = 0.91; Technological Scale: $\chi^2_{(36)} = 1661.55$; $p = .000$ and KMO = 0.75). In [Anonymised-author] (2019), we detailed the dimensionality of each scale, as well as their factor loadings, which were above 0.4 in all items.

To identify the current state of classrooms in Catalonia, a 10-item scale was designed, which addressed the same three dimensions. The environmental dimension comprised 3 items, the minimum number considered acceptable for a scale (Frías-Navarro 2019) (i.e. 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 (i.e. the classrooms in which I teach facilitate the development of learning formats that encourage cooperation). The technological dimension contained 4 items (i.e. 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 and Bernstein 1994) or even valid in 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 = .000 and KMO = 0.73). The analysis showed a structure of three factors that explain 58% of the variance, which corresponds to the factors in the scale. Item loads 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; availability of funds at the school to make changes to the space.

Table 1. Data gathering instrument

2.2. 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 40 schools. The teachers' response was not equal in each school, as they answered voluntarily. In compulsory secondary education, 342 teachers answered whereas in preschool and primary schools were 505 the teachers who answered (137 in preschool and 368 in primary education). The 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% men, reflecting the sector's female-male split. Most had more than 10 years of teaching experience (74.7%), 12% between 6 and 10 years of experience, and 13% less than that. A total of 83.4% worked in state schools, 14% in charter schools, and only 1.2% in private schools. The majority (79.4%) thought they could change the layout of their classrooms; and 46.3% said their school had the funds to do so, whereas 38% thought the school did not, and 16% did not know. Lastly, 49% had taken part in teaching innovation projects.

2.3. Data analysis

Prior to conducting the analysis, we first verified the instrument's reliability and validity using two methods. As an exploratory study, we conducted several analyses to establish 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 = .000 and KMO > 0.5). We adopted a factor loading criterion of 0.32 for inclusion of the item in the interpretation, 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. Details have been published in [Anonymised-author] (2019). Pearson's correlation tests showed significant correlations between the three scales (and high correlations between the environmental and pedagogical scales). The central tendency indexes and proportions are given for the descriptive analysis of the results. Comparisons of means with parametric tests are given, as they are tests of 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 being the 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.

3. Results

3.1. The reality of the classrooms in which the teachers teach

Regarding the first specific objective, the results show between low and 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 classrooms' environmental, pedagogical and technological dimensions

When the school's ownership is considered (Table 3), the environmental and technological dimensions show significant differences (p = .017 and p = .000, respectively). In both cases,

the charter centres score higher, perhaps meaning they have less traditional layouts and a higher integration of technology than in the state school classrooms.

When the educational level is considered (Table 3), the differences are significant within each dimension (p = .000 for all cases). Compulsory secondary education is where the most traditional conditions exist, 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.

Table 3. Classroom reality testing statistics and contextual variables

3.2. Perception of classrooms as SLS

The results regarding the second specific objective show the highest scores in 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.

Table 4. Scores of the perception scales

These results change when the socio-demographic and contextual variables are taken into consideration (Table 5). As regards age, significant differences are observed in the

pedagogical and technological scales (p = .048 and p = .039, respectively); younger teachers have a better perception (Bonferroni, p = .047) of the pedagogical aspects, and the 36-50 age group of the technological aspects.

With regard to the contextual variables, the educational level is a sensitive variable for all three scales (p = .000). In 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 = .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 = .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 = .045 and p = .001, respectively); in both cases, the teachers working in charter schools show a better attitude towards these aspects.

Furthermore, teachers show more favourable perceptions in all the scales when they have been involved in innovation projects (p = .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 = .029); the teachers in schools with funds have a better perception of the environment.

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

3.3. 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 (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. They, on their own, are 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 above all 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 in 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 classrooms' structural, pedagogical and technological design is important for facilitating change.

Cluster 2 (ability, weak perception of change) comprises 22.5% (n=170) of participants. They can implement changes but have a weaker perception in all the learning spaces' dimensions. This group consists above all of compulsory secondary school teachers, with teaching

experience, but who are older (they make 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 classrooms' 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). They are unlikely, on their own, to be able to implement changes and have a strong perception of 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 classrooms' 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 significance and therefore difference between the three profiles, except the technological scale in the case of the reality of the classrooms.

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

4. Discussion

The study allowed us to address the objectives, as discussed below. With respect to the first specific objective, we have seen that teachers tend to have a negative perception of their classrooms' actual suitability as SLS (Mulcahya et al. 2015). The classrooms allow diverse teaching methodologies to be implemented, but 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 in the reform-oriented sector of the school system for decades, embodied by Montessori and Helen Parkhurst's Dalton Plan schools, for example (OECD 2011). However, in mainstream settings, the classroom-based school has rarely been replaced or rethought as a socio-spatial assemblage (Dovey and Fisher 2014). The greatest efforts have been made in the earlier educational stages (Cabanellas and Eslava 2005). The results obtained show precisely 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.

The results also show that the best environmental and technological conditions are to be found in charter schools. Perhaps this is due to 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 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).

As regards 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, it can be observed that the integration of technology (fixed, mobile or robotic) shows the weakest perceptions, but the older teachers are, the more open they are 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 an older age 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, Dobson, and Petrina 2008). The younger teachers might be more critical about the real possibilities of integrating technology into the classrooms due to 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 and spaces: training and career background. Likewise, as was also the case with this study's first objective, this trend is reversed when the 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 to create 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, proving the close relationship that we know exists between innovation and change in the teaching mindset, even when the evidence of improvement is not always systematized (Goodyear and 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 expected result since 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 of the pedagogical and technological scales, but with no differences in the environmental scale, this time showing 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, Zimmer, and Buddin 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 have been 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 groups is their ability to implement changes in the school to create new learning environments, specifically, in the space with the greatest teaching load: 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, teachers show awareness of learning spaces, irrespective of whether or not they have the possibility to make changes in their immediate reality (Clusters 1 and 3). This could be explained by the calls for educational change since 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, which have a particular focus on innovative learning environments (OECD 2015) and are also impacting on teachers' perceptions and conceptions.

However, the more ambivalent teacher group is 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 the 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. And it is precisely in this power play that technologies play 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 the resistance to change.

These results should be considered indicators—sufficient and not always necessary—of teachers' perceptions, opinions and attitudes (Woolner, Hall, Higgins, McCaughey, and Wall 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 seen as a limitation of the research due to the nature of learning activities taking place in each school setting. However, as mentioned, the current study is one of the few that reports 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 very 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. Along with this, educational levels might be studied separately in forthcoming publications.

Another limitation relates to the second part of the non-random sampling, that of teachers. Although the sample has an adequate number of participants and there is a 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.

The results show a trend that will have to be confirmed in successive studies; however, they are necessary in a subject which has been little addressed in our context. It will be also important to explore what informed factors can help predict positive perceptions of change in teachers, through predictive techniques. But not only is the quantitative approach sufficient, it is also desirable to conduct studies under mixed or qualitative comprehensive approaches, which helps 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—, overall this study provides empirical evidence on the different degrees of favourability 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 informing the decision-making of administrators, management teams and teachers in envisioning and conceptualizing learning environments, as well as their interventions in schools. They are also addressed to educational policy leaders and funding and management teams, for the reasons outlined below.

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, the 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. And the more 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 the 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. This being said, 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 how the objective of secondary school teachers is far removed from changes and innovations. Future university entrance exams at the end of secondary education have become the main goal of many centres, curbing any 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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Tables

Table 1. Data gathering instrument

Dimensions	Items	Measurement scale
Socio-demographic and contextual data		
	Teacher's gender	Categorical dichotomous
	Age	Scalar
	Years of teaching experience	Categorical
	Education level at which most of the teaching is given	Categorical
	Ownership of the school where the classes are given	Categorical dichotomous
	School's geographical location	Categorical
	Capacity to change the classrooms' 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	Scalar (1 to 5) α= 0.6
	Pedagogical dimension	
	Technological dimension	
Classroom perception scale (27 items)		
	Environmental aspects perception scale (9 items)	Scalar (1 to 5) α= 0.76
	Pedagogical aspects perception scale (9 items)	Scalar (1 to 5) α= 0.87
	Technological aspects perception scale (9 items)	Scalar (1 to 5) α= 0.7

Table 2. Scores for classrooms' environmental, pedagogical and technological dimensions

	N	Minimum	Maximum	Mean	SD
Environmental dimension	841	1.67	5.00	3.3607	.69895
Pedagogical dimension	839	1.00	5.00	3.4009	.93174
Technological dimension	821	1.00	5.00	2.7329	.84257
Total	807	1.50	4.90	3.1160	.55143
Valid N (by list)	807				

Table 3. Classroom reality testing statistics and contextual variables

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

Table 4. Scores of the perception scales

	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 the teachers' perceptions and the socio-demographic and contextual variables

		Environmental scale			Pedagogical scale			Technological scale		
		Mean	Test	Sig.	Mean	Test	Sig.	Mean	Test	Sig.
Age										
	< 35	4.10	F=	.075	4.25	F=	.048	3.46	F=	.039
	35-50	4.03	2.60		4.14	3.04		3.58	3.25	
	> 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=-	.029	4.20	T=-	.187	3.55	T=-428	.668
	No	3.99	2.18		4.13	1.32		3.53		
Education level										
	Infant	4.35	F=	.000	4.39	F=	.000	3.36	F=	.000
	Primary	4.14	71.37		4.32	62.81		3.51	8.43	
	Secondary	3.74			3.83			3.60		
Ownership of the school										
	State	4.01	T=-660	.510	4.11	T=-	.045	3.49	T=-	.001
	Charter	4.04			4.23	2.01		3.69	3.38	
Have taken part in innovation projects										
	Yes	4.12	T=-	.000	4.23	T=-	.000	3.61	T=-	.000
			4.66			3.76			4.44	

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

Quantitative variables		Cluster 1	Cluster 2	Cluster 3	F	p
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
	Infant	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%		

Figures

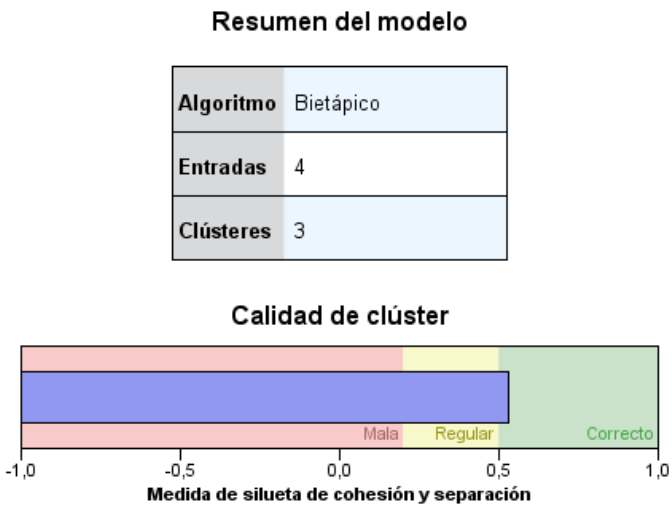

Figure 2. Cluster quality in the two-step cluster analysis