The Integration of Digital Devices into Learning Spaces According to the Needs of Primary and Secondary Teachers

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Abstract **– Current educational paradigms require new learning spaces that should be designed and modified following guidelines for the pedagogical needs and from a stance that is both realistic and sustainable in its implementation, but above all superior quality systematic research. For that reason, the aim of our research is to identify the needs and perceptions of a teacher in relation to the technological design of classrooms. Explanatory investigation has been carried out by means of a quantitative study. The results point to it being necessary to re-configure the classrooms and break with the traditional layout of the learning space. It should be noted that digital dimension should act as a foundation for proposing new learning spaces in schools.**

Keywords **– Digital technology, learning spaces, quantitative study**

1. Introduction

The advances in educational theories and paradigms in recent decades, as well as the emergence of new approaches and pedagogical strategies based on the scientific knowledge of how learning processes are developed [14] for the focus of priority attention on the research into what changes the configuration of learning spaces in educational centres should undergo (principally, the classrooms and subspaces of which they are configured or are located around them).

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In addition, analysis of the conditions, dynamics and methodologies that are developed in these spaces is necessary [4],[5],[12],[13],[30]. Current educational paradigms require learning spaces that are nothing like those usually found in schools. These spaces should be designed and modified following the guidelines for the pedagogical needs and from a stance that is both realistic and sustainable in its implementation, but above all superior quality systematic research.

Our research into school learning spaces begins with the identification of the problem caused by the limited focus placed on the conceptualisation and configuration of the classroom as the driving force behind innovation for teachers and learning for students, and the minor changes that have occurred in this main learning space for the teaching and learning process. Especially in what is referred to as the integration of digital technologies in the configuration of learning spaces within the framework of current educational theories and paradigms.

Using this problem as a starting point, the aim of our research is to identify the needs and perceptions of the teacher in relation to the technological design of classrooms.

We begin with the consideration that it is essential to establish a relationship between classroom design and the use of technology as a support for learning tasks, following a set of psycho-educative principles that should guide the educational practice, which means that knowledge is generated from the research, allowing us to make decisions grounded in this field.

2. State of the Art

The teaching praxis currently finds itself undergoing changes regarding the conception of learning processes and new approaches and resources. Attempts are being made to break with a didactic background defined by a traditional educational culture and with the purpose of adapting to the needs of students and society. Not only have students and society incorporated new uses for their environment and digital tools, they are moving towards new ways of communicating, new

collaborative work models and networks. In addition, they seek more flexible, horizontal and efficient new ways of organisation [22] and the integration of learning spaces which should be designed with the welfare of those who inhabit them in mind and to encourage, amongst other things, creative, social and open teamwork [23].

International reports [26], [14] indicate that the improvements in education are the result of multifactorial work, where amongst other factors, there has been a change in the organisation of the space towards more flexible locations, and so breaking with the rigidity of time and space in primary and secondary schools in favour of new learning dynamics. Furthermore, other studies [6], [8],[9] demonstrate specifically how some of the factors related to the change in the organization, the use of educational space and the conditions have a positive effect on academic results, as well as the welfare and level of satisfaction of students and teachers. These studies also reveal a growth in interest from teachers, educators and management in educational centres to combine the processes of pedagogical innovation with changes to the learning space.

All of this suggests the need for the design of a new generation of classrooms and spaces [1], [2], [3], [27], educational spaces that permit the combination of learning activities, which focus on investigation, where the student is proactive and takes an open and constructive approach while using digital technologies. The learning spaces are structurally adapted to the different moments and needs of the learning process while also facilitating it.

However, as has been proven in previous studies [1], [2] there is not much research that focuses attention on the analysis of the configuration of the academic learning space and even less that does so in relation to a culture of innovative teaching, pedagogical principles and specific didactic methodologies, especially those that consist of an intensive use of digital technologies.

At the present time, although there is no single model as to what defines a good learning space [3], [11], the review conducted confronts us with the existence and discussion of three dimensional analysis that is key to its conceptual design: the environmental dimension, the pedagogical dimension and the digital -technological dimension. With regard to the environmental dimension, [6] have established a series of elements to consider in the architectural design, such as the stimulation that the setting induces through colour and textures, the visual sensation of order and balance, naturalness, or light, sound, temperature and air quality.

On the other hand, the pedagogical dimension of the conceptualisation and design of the classrooms is concerned with analysing how the pedagogical paradigm that guides the didactic practice must also guide the decisions related to the learning space. Intelligent classroom design will allow a response not only to different learning moments but also to different methodologies. In recent years the ILE Project (Innovative Learning Environments) by the OECD has studied the conditions and dynamics that permit better learning. The recommendations for educational environments that stem from this study, indicate that the whole learning ecosystem needs to be considered, including how the environment conditions and facilitates the learning activity of students.

Finally, regarding the digital dimension, the implementation of this type of technology in educational systems does not necessarily mean improvements and advances in the teaching and learning environment. Nonetheless, many authors agree that digital technology is an opportunity for changes to the educational system. In tech-rich spaces, digital technologies can play several key roles in the process of change, including the possibility of adapting learning to the individual needs and pace of students, although with a dual responsibility [19]. Firstly, using technologies didactically in order to enhance learning (access to information, motivation, immediacy, personalisation, communication, etc.). Secondly, the classroom is converted into a place of digital training, since these skills are already a reality that have an intense effect on the development of people and are necessary to prosper in a digital society [15].

Many of the changes in the learning space have only ever been linked to the integration of technology, without comprehensively incorporating a pedagogical or environmental change into the space. Some authors [27] refer to them as spaces where devices and software are found. These are primarily educational (for example, intelligent whiteboards, learning objects, virtual learning environments, intelligent systems, among others), of which the teacher adapts and integrates their didactic unit.

In the same vein, indicate that these spaces incorporate many different types of hardware, including computers, tablets, interactive whiteboards, workstations, and many other integrated uses of these technologies for instructional purposes. According to this approach, learning spaces are defined as places where technology is integrated into the space in response to different activities. While the technological aspects are present, these definitions do not account for the educational values.

In this way, most of the changes have been superficial, such as with the incorporation of some type of digital device [7]. The introduction of digital technology has not led to pedagogical changes as, in

many cases it has reinforced the already existing behaviors and pedagogies [29]. These superficial spatial changes stem from a lack of understanding of the integration of digital technology. This affects the physical and social conditions of the classroom environment [20]. An example of this is how projectors and interactive whiteboards have been installed. In general, they have been placed at the front of the classroom and so reinforce the pedagogical strategies that focus on the teacher as a lecturer [28].

The effectiveness, the use and the value of digital technologies is affected by the space and the methodology. Different spatial configurations have a measurable effect on how students perceive the effectiveness of technological resources. However, evidence suggests that any change to the learning space in and of itself does not improve learning.

One of the main elements that should be guaranteed in the learning space infrastructure, with respect to technology, is connectivity by way of the different options in existence, for example, Bluetooth or Wi-Fi. This connectivity should allow students and teachers to comfortably carry out different tasks in a digital format and through a digital medium, such as quickly and consistently searching, sharing and creating information and knowledge [21].

However, even though a space may be tech-rich, this technology should only be a resource for teachers and students, therefore, the design of the classroom should ensure its presence is not [16]. While also being a permanent fixture for students and teachers, it should function as an instrument of intellectual activity and a tool for collaborative construction of knowledge.

This multidimensional approach leads the direction of the discussion on the importance of incorporating and systemising the different elements that we propose, so that they are taken into consideration when configuring and designing new learning spaces in educational centres.

3. Method

Explanatory investigation has been carried out by means of a quantitative study with the general aim of analysing the perceptions and needs of teaching staff with respect to the configuration of the classroom as a learning space, specifically with the digital dimension in mind.

Detailed objectives:

- Determine how fixed, mobile and robotic digital technology devices are integrated and interacted with in the classroom according to the needs of the teaching staff
- Analyze the differences that exist with respect to the integration of digital devices among teachers of different educational stages
- Analyze the difference that exists with respect to the integration of digital devices according to the sociodemographic data (Sex and age)
- Show teachers that the digital elements and features are indispensable in the classroom

The survey method was used and took from a final sample of 136 pre-school teachers, 355 primary teachers and 333 secondary teachers. The sample was representative of an analysis of the teaching population in Catalan educational centres (62,733 pre-school and primary teachers; and 43,322 secondary school teachers) during the academic year 2017-2018. This sample has a margin of error of ± 3.5, for a confidence/trust level of 95.5% in infinite populations, where p and q are the same. Participants were selected using convenience sampling [18], which is characterized by the selection of easily accessible participants.

The means for data collection was a questionnaire based on a five-point Likert Scale (strongly disagree-1-, disagree-2-, neither agree nor disagree/undecided-3-, agree-4-, strongly agree-5-). In order to create the scale, a set of baseline indicators for the digital dimension was identified beforehand, and afterwards it became 9 guidelines:

- The classrooms where digital technology is integrated must have a different configuration of the space to that of a traditional classroom
- Mobile screens (mobile phones, tablets, etc.) need to be integrated in the classroom
- The school internet connection must allow students to be able to access the internet at any time and in any place
- A specialist computer room is not necessary because the technology must be available in any classroom as and when it is needed
- I agree with the "bring your own device to the classroom" (BYOD) movement
- I agree with the "make students become the creators in the classroom" trend, by using ICT (for example, the Maker movement with 3D printers, Arduino Kit, etc.)
- Integrating robotics and/or programming which promote the creation of classroom scenarios in which students are the protagonists of their learning
- A desktop PC connected to a projector is essential in the classroom
- A digital whiteboard is essential in the classroom

In addition to the 9 guidelines, an open question was added in order to be able to compile the characteristics of the specific elements and devices required by teachers in their classrooms:

- What elements of digital technology would your ideal classroom have? (Number of devices per student, type of device, etc.)

The reliability of the scale was calculated by means of Crombach's Alpha internal consistency index, which produced a result of 0.70. Expert opinions were used to validate the content. Showing broad agreement with the relevance and importance of the opinions proposed in each of the scales. For the construct validity, factorial analysis was applied by means of the Principal Component Analysis method with Varimax rotation. The KMO test demonstrated the significance and adequacy of this analysis (p =, 000 and KMO > 0.5).

Furthermore, the questionnaire included other variables that describe the demographic and contextual aspects: age, sex, years of teaching experience, educational level taught, type of educational centre employed in, geographical location of the centre, interest in innovative teaching (measured through participation in innovation projects); and finally, capacity to make the decision to change the distribution of the classrooms where they teach.

4. Analysis Results

For the descriptive analysis of the integration of digital devices in the classroom, central tendency indexes and ratios are submitted. In order to investigate the influence of certain variables in the results of the scale, comparisons of means (with robust parametric tests) and correlations are submitted. All the earlier operations were carried out using the statistical package SPSS, version 18.

The open question was analysed using the Nvivo programme, specifically nodal analysis, in order to regroup them and find the common characteristics. In the analysis of word frequency, 11428 words have been compiled. Lastly, the code array is used to compare the material encoded in the nodes, sets, and attribute values.

5. Results

Firstly, the sociodemographic data of the final sample is composed of 80% women and 20% men. In terms of age, 20.4% were under 35; 55.3% were between 36 and 50; and 24.3% were older than 51. The centres where the teachers were employed were 83.4% public and 13.9% semi-private.

5.1. Integration of Ffixed, Mobile and Robotic Devices in the Classroom

The data shows that, for teachers, the integration of digital technology requires a layout and configuration of the space that is different from traditional classrooms (mean of 3.9 over 5, with a standard deviation of 1.07). In this way, most teachers find the need to modify the traditional arrangement (tables and chairs facing the blackboard) to a different configuration of the space.

On the other hand, many of the teachers surveyed use digital technology in the classroom, with most opting for the integration of mobile technology, though not so many opt for robotics-related elements. In relation to the item "Integrating mobile screens (mobile phones, tablets, etc.) in the classroom is necessary", the result is a mean of 3.75 relative to 5 (with a standard deviation of 1.09). Furthermore, many teachers support the "bring your own device to class" (BYOD) movement, with a mean of 3.25 (and a standard deviation of 1.3). They think that mobile devices are necessary in the classroom and should be owned by the students.

The item that most teachers agreed on was internet connectivity. Teachers specify that the connection should be accessible at any time and in any location.

Table 1. Internet Connection

It is necessary that the Internet connection of the center allows students to access the Internet at any time and in any location	N	Min.	Max.	Mean	Standard Dev.
	843	1	5	4,35	1,077

The mean decreased to 2.03 (with a standard deviation of 1.2) when asking about the need for a desktop PC connected to a projector. Thus, some of the teachers, not only do they need mobile technology in the classroom, but also a fixed computer and a projector. In addition, with a mean of 2.37 (and a standard deviation of 1.2) there is a need for teachers to integrate a digital whiteboard.

Regarding the traditional computer room, teachers revealed (with a mean of 4.1 and a standard deviation of 1.1) that they do not require this type of classroom since the technology should be available in the classroom as required.

On the other hand, when asked about devices related to the Maker movement (3D printers, laser cutters…) and robotics (Arduino kits, Bee Bot, Lego...), overall teachers are generally in agreement, with a mean of 3.9 and 3.92 respectively.

5.2. How the Iintegration of Digital Devices Differs Between Educational Stages

The following table shows that when differentiating between different educational stages, some minor differences appear as regards the integration of digital devices in the classroom, all of which are significant. Secondary education is the educational level where technology is most integrated, with a mean of 3.13, followed by primary education (2.49) and thirdly, pre-school education is the level where these devices are least integrated into the classroom (2.28).

Table 2. Integration of digital devices in classrooms according to educational stage

	N	Mean	Standard Deviation	Confidence Interval for the mean at 95%	
				Lower Limit	Upper Limit
Pre-school	129	2.282	, 72979	2.155	2.410
Primary	345	2.493	, 73418	2.415	2.571
Secondary	325	3.135	, 80851	3.047	3.223
Total	799	2.720	, 84055	2.662	2.779

The items that have resulted as statistically significant between the different educational stages are those related to the integration of mobile devices "It is necessary to integrate mobile screens (tablets, mobile phones, etc.) in the classroom. Pre-school teachers agree with a mean of 3.44 as opposed to secondary school teachers with a mean of 3.83. Similarly, in relation to bringing one's own device to the classroom, pre-school teachers agree with n 2.61 compared with 3.8 for secondary teachers.

5.3. How the Integration of Digital Devices Differs Among Sociodemographic Variables

The importance of integrating digital devices in the classroom is viewed in the same way by both sexes, with the responses being moderate in both cases. As regards age, significant differences can be observed (P =,039 respectively). The youngest teachers, when compared with the oldest teachers, that are aged between 36 and 50, have a more positive outlook on technology.

Table 3. Integration of digital devices in the classroom according to socio-demographic variables

		Technological Scale		
		Mean	Test	Gis.
Sex	Woman	3.51	T =-0.90	.365
	Man	3.56		
Age	35 or less	3.46	F = 3.25	.039
	36-50	3.58		
	More than 50	3.50		

Although there is not much meaningful difference between the sexes in general, if the items are analysed individually, some differences appear. In most aspects related to the integration of devices in the classroom both sexes agree. For example, the integration of technology also implies changes to the learning space, breaking with a traditional layout. However, in most items, women agreed less with the integration of digital devices, especially mobiles.

The items in which there is a lower degree of agreement are: "An Interactive digital whiteboard is an essential element of the classroom. (3.69 v 3.36) "and " I agree with the "bring your own device to class" (BYOD) trend. (3.19 v 3.51)

The questions with statistically significant differences are:

Table 4: Differences between sexes with respect to the digital whiteboard

	Sex	N	Mean	Standard Deviation	Standard error
An Interactive digital whiteboard is an essential element of the classroom	Female	659	3,69	1,246	,049
	Male	164	3,36	1,315	,103

This is one of the least agreed with items, but even so it is still above 2.5, therefore showing agreement. Women consider a digital whiteboard to be more essential.

Table 5: Differences between sexes with respect to mobile screens

Mobile screens (mobile phones, tablets, etc.) need to be integrated into the classroom	Female	655	3,71	1,081	,042
	Male	164	3,98	1,105	,086

They moderately agree with the integration of mobile screens, although in this case women can be observed/seen to agree less than men.

5.4. Digital Elements in the Classroom that are Essential for Teachers

To analyse the open question, "What elements of digital technology would your ideal classroom have? (number of devices per student, types of devices, etc.) The information has been grouped into 3 categories:

1. Device Type (e.g. computer; digital whiteboard; tablets; laptops; Chromebooks; cameras…)
2. Number of students per computer (1 computer per student; 1 for every two students; tablets for groups...)
3. Layout of the space (computer corner; computer room; distributed around the classroom...)

In response to the first category, most teachers (86%) referred to the type of device, 43% the number of devices per student, and only 9% the layout of the space.

Regarding the device type category, in the pre-school stage teachers have more frequently stated that in their ideal classroom they would need a digital whiteboard (44.9 Prominence and 5.4% Frequency), followed by desktop PC (45.1 Prominence and 4.1% Frequency) and tablets (78.8 Prominence and 3.4% Frequency), as well as projectors.

The variety of digital technology does not extend far beyond the devices mentioned above. Only three teachers have requested Beebot (3 Expression Count), two teachers a camera (2 Expression Count), and one teacher a binocular loupe with a moticam.

With respect to the number of devices, pre-school teachers also tend to agree with each other. Of the teachers who requested a digital whiteboard, all of them asked for one per classroom. The same occurred with desktop PCs, they all need one with an internet connection. On the other hand, with tablets, the teachers who requested this technology have a very different opinion regarding the number of devices. This varies from two per classroom to one per student.

Finally, teachers who referred to the distribution of space commented that they would prefer a corner in the classroom where several devices are available, for example laptops or tablets.

"A corner with 4 computers and little tables”

It should be highlighted that 2% of teachers are in favour of not integrating any element of digital technology in the classroom:

"I think at this age there are other more necessary elements/materials”

"No digital devices. What they need is material they can touch and feel"

On the other hand, primary teachers have different needs to their pre-school peers. Although a digital whiteboard appears with high frequency (64%) for teachers the need for a laptop exceeds this (76%). Tablets are also a highly requested element. Nevertheless, it must be highlighted that many teachers (46%) have not specified the type of device, just the quantity. They are therefore indifferent to the type.

With respect to the number of devices, the results show a wide variety of options on the part of the teachers. The general trend at this stage is for a double request, one device per pupil (4 expression count, 0.4% frequency, 97.3 prominence) or one device per two students (3 expression count, 0.3% frequency, 21.9 prominence). Although many teachers (39%) make specific requests, as shown below:

"At least 6 desktop PCs per 2 students, 4 laptops, 4 cameras, and four more video cameras, plus a couple of tablets”

"The minimum would have to be: a digital whiteboard, 5 computers, 8 tablets”

It should be highlighted that some teachers (12%) also request a computer room (2, 0.2 and 15.3)

Finally, regarding secondary school teachers, it is obviously the group that requests a greater variety of digital technology, much of which is related to robotics (2 expression count, 0.1% frequency and 40.2 prominence) or 3D printing. However, devices such as projectors (4 expression count, 0.1% frequency, 40.3 prominence) or digital displays (3 expression count, 0.1% frequency, 60 prominence) still have strong representation.

The number of devices at this stage is clearly focused on one device per student (47 expression count, 12% frequency 40 prominence), with teachers choosing laptops as much as tablets.

6. Discussion

In the following paragraphs the results will be discussed according to the research objectives set out at the beginning of the study. As regards the first objective, determining how digital technology devices are integrated and interacted with in the classroom, teachers consider it necessary to re-configure the classrooms and break with the traditional layout of the learning space. This result is in line with the view of some authors [10], [9], [24]. who suggest the need to design a new generation of classrooms and spaces that would allow the combination of discovery based learning activities with a proactive approach from the students.

In addition, the results demonstrate that a traditional computer room is not quite so necessary because the technology should be available in the classroom as and when it is needed. Accordingly, what teachers do consider necessary is a schoolwide internet connection that permits students access the Internet at any time and in any location. There is no clearly defined opinion as to how classrooms should be configured in order to integrate digital technology. This has also been shown by research, which expresses that there is no single defined model of a good learning space [11].

In reference to the second objective, upon analysing the differences amongst teachers of the different educational stages in relation to the integration of digital devices, we find that as in the case of mobile technology, the data demonstrates that teachers do use technology in the classroom but there has been limited integration of robotics and/or programming to create classroom scenarios in which students are the protagonists of their learning. In general, the educational stage where technology is most integrated in classrooms is secondary education, followed by primary education and in third place pre-school education.

On the other hand, when analysing how the integration of digital devices differs depending on the socio-demographic data (sex and age), we see that contrary to what we may think, it is older teachers who are more likely to consider the integration of technology in the classroom as necessary. Perhaps this finding may be linked to 'computer and technology literacy', given that research indicates that being more accustomed to digital technology does not necessarily mean that one is more capable of using and integrating it on a daily basis [17]. In this case, younger teachers may also be the most critical of the real possibilities of integrating technology in the classroom, due to their greater exposure to it.

7. Conclusion

It should be noted that digital dimension should act as a foundation for proposing new learning spaces in schools. However, it is important to keep in mind that the design should be based on a philosophy of education, within a theoretical pedagogical framework [25], [6]. Thus, permitting us to know what is being done and the motives that lead to certain decisions being made as regards the concretion, interrelation and integration of each of the design principles. There is a clear need to know the motives that lead to decisions being made in either case, without being misled by tradition nor by meaningless and baseless innovation. Only in this way can we justify what is being done. Accordingly, it is essential to establish a dialogue between the design of the classroom, the use of technology as a support for learning tasks and the psycho-educative principles that have emerged from the research and that they should guide educational policy and practice internationally.

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