The Classroom Physical Space as a learning ecosystem

Bridging approaches: results from a web survey

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Abstract. The classroom physical space enfolds several dimensions such as the social, cultural, architectural and technological. The current scenario of digitally equipped classrooms in which new pedagogical approaches based on collaborative learning, project-based learning and personalized learning are being used, call for the need to rethink the classroom physical space. Despite of the existence of some new classroom physical spaces aiming to answer this new reality, like the Future Classroom Lab, we argue that there might be lacking an innovative interior design strategy encompassing these aspects and fulfilling all the classroom physical space dimensions. Thus, this paper aims to present the perspective the authors have concerning the classroom physical space as a learning ecosystem and to start building the bridges between different approaches to space and relating them to the classroom physical space, in order to create an innovative interior design strategy that will improve the use of classroom physical space in its different dimensions. We also present the first results of an European web survey applied to the European Schoolnet Future Classroom network members that aimed at understanding how their spaces were thought and how they are being perceived; a brief discussion of the results, which, overall, are positive, is also presented. The paper ends with some references to the future work.

Keywords: classroom physical space, smart learning ecosystems, classroom orchestration, enabling spaces, human-building interaction, smart classroom, spatial semiotics, spatial pedagogy

1. Introduction

This paper is part of an ongoing research that aims to investigate the role of innovative interior design strategies in creating new classroom spaces. Acknowledging that the Classroom Physical Space (CPhS) interacts and depends directly on several different dimensions among which the social, cultural and digital, a new space (Sardinha et al. 2017) is going to be designed aiming to promote the inclusion of specific populations, namely the youngsters that are Not in Education, Employment or Training (NEET) and Refugees.

Several approaches to the space are introduced: classroom orchestration, the enabling spaces, Human-Building Interaction (HBI), the smart learning ecosystem and smart classrooms, in order to start creating bridges among them.

Some of the data already collected through an European web survey regarding the use of the Future Classroom Learning Labs (FCLL) is also presented.

2. The classroom physical space

The research on the classroom physical space involves the development of a multidisciplinary approach that must consider different dimensions and contributes from several domains as the classroom orchestration (Dillenbourg and Fischer 2007; Dillenbourg and Jermann 2007), the enabling spaces approach (Peschl and Fundneider 2012), the HBI (Alavi et al. 2016b, a) and the spatial semiotics and spatial pedagogy (Lim et al. 2012). In our perspective, all these have in common the high relevance given to the social dimension of the CPhS that, together with the technological one alongside with the spatial semiotics and the spatial pedagogy plays a relevant role in the creation of a smart learning ecosystem.

When considering the specific target population of the project that frames this paper (NEET and Refugees), it seems relevant to better understand how can these dimensions shape a new context and help to create smart spaces that might potentially enhance a more inclusive and better CPhS, i. e, "*a context where the human capital(and more in general each individual) owns not only a high level of skills, but is also strongly motivated by continuous and adequate challenges, while its primary needs are reasonably satisfied*" (Giovannella 2014a, b).

2.1. A contextualization of the classroom physical space history

According to Park and Choi (Park and Choi 2014) the classroom physical space has been connected to the educational approaches through time. In ancient Greece there was a rhetorical/dialogical system and there were neither a specific space for

the classes to happen, nor a rigid setting for the teacher and the students to be. These latter would place themselves around the teacher in no particular order.

When a more formal education appeared with the medieval Universities, a more rigid layout set place and evolved to a very strict layout with the spreading of Universities. During this time, the educational system was teacher-centred, and the classroom layout reflected this centrism, occupying the teacher a featured place in the classroom. With the expansion of Universities and schools, the medieval layout remained, however adapted to a bigger space (figure 1).

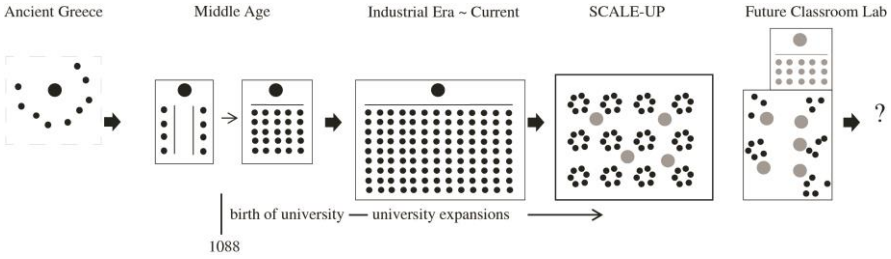

Fig. 1. Adaptation of the fig."Historical changes in classroom design" by Park and Choi (2014)

In the last century the pedagogical approaches started to change, although the classroom space and layout, in general, did not reflected these changes. Towards the end of the XX century and, in particular, in the beginning of the present one, the CPhS started to be reconfigured. Not only is this change of paradigm due to the technological penetration in the classrooms, but also to new pedagogical approaches that came with it. The SCALE-UP (Burke 2015) space and the Future classroom Lab (FCL) (European Schoolnet 2016) are good examples which translate this educational shift.

2.2. The space approaches to create bridges

In our perspective, and alongside with some other investigators (Dillenbourg et al. 2011; Peschl et al. 2014), the classroom is a complex system that combines different dimensions as the social, cultural, architectural and digital, among others. Even if there is a mental image of "four delimiting walls" connected to the classroom space, we approach this latter as going further and outside the walls. Thus, the way the inside walls is thought and designed should broaden it across its physical boundaries. In order to comply this, digital technologies can play a very important role in creating new scenarios that can better enable the learning processes, through a technological enhanced environment (Giovannella 2014a).

2.2.1 Spatial Semiotics and Spatial Pedagogy

Space is a way of communication and in order to understand the way it flows through space distance (Hall 1959) and its dynamics (Stenglin 2009), it is important to master its language. The built edification can be defined through: a) an Euclidean perspective as the architectural space (Peschl and Fundneider 2012) or the built space (Stenglin 2009)relying, in part, in static and dynamic resources (Stenglin 2009); b) the "constructed" space between walls which cannot be detached from a social dimension brought up by the interaction and interpersonal relations between its users (Stenglin 2009; Perolini 2011). This social dimension, together with a cultural one, reflects on how space is organized (Hall 1959) as each culture experiences it in its own way (Hall 1990).

In which concerns CPhS, and more specifically to the classroom spaces conceived meanings, a way of experiencing space is often times present in the interactions between teachers and students and space itself, or spatial semiotics (Lim et al. 2012). This latter is perceived through the way they move athwart space and its signification and their paths (Lim et al. 2012). The different paths and their quality constructed through movement across the space may measure fluidity.

The study of the movements and its positions and directions, allow the arising of patterns enabling the analysis of the dynamic of the physical space. The positioning and directionality of movements in a classroom usually are not random, having a meaning, as well as face expressions, gestures and the voice intensity. These encompass a semiotics dimension, which alongside with the language and pedagogical ones, among others, define spatial pedagogy (Lim et al. 2012).

2.2.2. The classroom orchestration

Classroom orchestration, and in particular, Dillenbourg's perspective of it, ensue from the ability to manage a technological enhanced environment (like the Computer Supported Collaborative Learning environment - CSCL) , not only through the core of instructional design (kernel) but also through observing learners during their activities and making the necessary adjustments to learners instructions whenever needed (towards personalization) (Dillenbourg et al. 2011). To Dillenbourg, the "rings around the kernel" cannot be neglected, even those that might look out of place as the rings which address logistics. Though, Dillenbourg argues the existence of constraints to both kernel and rings, being the kernel constraints related to: what (the curriculum), what is inside (the contents), and who (how people learn as well as the learners themselves). What regards the rings constraints, or the "designing for orchestration", Dillenbourg considers these to be constraints related to the assessment, time, discipline, energy and space (Dillenbourg et al. 2011). All these constraints (both of kernels and rings' have a deep influence on the teacher's work, meaning that the author considers the teacher's role as having the most importance in classroom orchestration and proposes their empowerment, in order to increase student's achievements via problem solving situations and group discussions. This empowerment should not be achieved by simply placing

the teacher as the commanding agent, but as the one that scaffolds and enhances students' motivation towards successful achievements, through design factors (leadership, flexibility, control, awareness, etc.).

Classroom orchestration in the referred perspective aims to provide a better learning ecosystem (physical, technological, social, personal, emotional) to students in order to scaffold and enhance their knowledge acquisition.

2.2.3. The Enabling Spaces approach

Peschl and Fundneider define Enabling Spaces as multidimensional spaces (architectural, social, emotional and technological dimension spaces, among others), which enable, facilitate and support the knowledge creation and innovation processes. For the authors, the optimization of new knowledge creation is empowered by the multidimensional spaces, each one corresponding to a different dimension, which must be "orchestrated in an integrated manner" (Peschl and Fundneider 2012) as well as in an interdisciplinary way overcoming the possible constraints and conditions (Peschl and Fundneider 2012).

When applied in the educational context, the Enabling Spaces approach also encompasses the pedagogical choices and the didactical environment, as well as the teachers' personality (beliefs and thoughts) alongside with the different spaces/dimensions mentioned above (Peschl et al. 2014).

Therefore, in the Enabling Spaces approach "the integration and orchestration of different spaces/ dimensions (…) is one of the most challenging problems, yet powerful features" (Peschl and Fundneider 2012). In order to overcome this challenges, Peschl and Fundneider stress the importance of supporting and leading the Enabling Space interdisciplinary through a well-founded design process (Peschl and Fundneider 2012).

2.2.4. Human-Building Interaction

HBI brings forward the relation between Human-Computer Interaction and buildings. As these latter are becoming more and more technological based, like in the Smart Homes, Alavi et al (2016b) argue that buildings ought to be developed and designed with a dialogical relation between its users (either in the social and individual levels) and their "digital and physical interactive daily experiences" (Alavi et al. 2016b).

HBI approaches buildings through Hillier's perspective (Alavi et al. 2016b, a) in which besides the physical and spatial form these also have a social-cultural function (Hillier 2007).

According to the HBI authors, "Designing HBI (…) consists of providing interactive opportunities for the occupants to shape the physical, spatial, and social impacts of their built environment" (Alavi et al. 2016b).

2.2.5. Smart Learning ecosystems and the Smart Classroom

Smart learning ecosystems encompasses not only the students, teachers and school staff as "individual actors of the learning process" (Galego et al. 2016) but also the stakeholders, surrounding community, family, "services, social life, challenges, skills" (Galego et al. 2016) inherent to the learning environment. Smart learning ecosystems, apart from the smart technology, devices, applications and its infrastructures, relies also in "help[ing] towards achieving a people centred smartness, through streamlining mundane organisational tasks, and enhancing the skills of all actors involved in learning processes" (ASLERD 2016).

Bautista and Borges state that the concept of smart classroom arises from the intersection between "classroom's architectural design and its ergonomy", smart technology and pedagogical approaches "as collaborative learning, project-based learning, (…) students' autonomy, educational co-responsibility, etc" (Bautista and Borges 2013) relying also on the actors' learning processes.

2.2.6. Bridging the space approaches

Physical spaces when detached from their social and cultural dimensions risk to lose their meaning. Thus, when approaching the CPhS, we intend to create bridges between the referred space dimensions and to develop an innovative interior design strategy to the CPhS. In this process, we will give relevance to the social and cultural meanings of the physical space, as well as to the interaction opportunities and the state of flow of all agents involved. To study these interaction opportunities is central and we must consider three main dynamics: between users and technology, between users and space and among users themselves.

3. The web survey

We applied a web survey aiming to understand how the FCLL from the European Schoolnet FCL network members were thought and conceived and how these are being used. It targeted the Decision Makers (DM), the Decision Makers which are also Teachers (DMT), Teachers (T) and Students (S).

Section 1 was presented to characterize the participants and it was common to all the groups, as well as section 6.This intended to gather a list of the technological solutions in use in the FCLL, as well as to understand how the FCLL layout is being displaced.

Section 2 and part of section 3, targeting DM and DMT, aim to understand what reasons/factors led to the decision making of implementing a FCLL in the school and how these spaces were thought/conceived.

The remaining sections 3 and 4, this latter targeting teachers, is almost identical to the students' section (section 5). These aim to understand how the FCLL are being used by teachers and students and their perception of it through a 5-point Likert scale (strongly disagree to strongly agree). The questions were categorized in physical space, space communication, emotional space, teaching/learning space, social space and technological space.

3.1. The participants

The online web survey dissemination was done by email and Facebook. An email was sent to all the contacts available on the FCL website in November 2016 and to the European Schoolnet. There were 26 FCLL from 12 countries of which: Portugal (9); Belgium (4); Germany, Israel and Norway (2); Croatia, Cyprus, Czech Republic, France, Italy, Slovakia and United Kingdom (1). They were asked to spread the web survey to all the DM, DMT, T and S using the FCLL. The European Schoolnet posted the link to the web survey on their Facebook page.

107 complete questionnaires were collected, from which: 3 DM (3%), 10 DMT (9%), 11 T (10%) and 83 S (78%). To what concerns the gender, despite 82% being male, if we consider the DM, DMT and T alone, then we have 67% being female. The age mean is 23 years old with a standard deviation (SD) of 12; however the age mean concerning the DM, DMT and T is 44 years old (SD 9,16), being the oldest 66 years old and the youngest 32 years old. The students' age mean is 17 years old (SD 1,59), being the oldest 25 years old and the youngest 15 years old.

Most of the participants, 94%, are from Portugal (101) including all the students, being the other 6 participants from Belgium (1), France (1), Israel (1), Italy (2) and Norway (1). In what concerns the type of school where the FCLL are located is worth to mention that 82% (89/107) of the respondents, of which 82 students, are from the same school – a Portuguese VET School[1]. The others are: Elementary School (1), Middle School (4), High School (4), University (4), Norwegian Education Government (1), Showcase (1), ICT Centre (1), Teacher Training Centre (1) and Cluster of Schools (1).

3.2. Results and discussion

The results hereinafter presented concern to the relative frequency of the quantitative data collected and are organized according to two main items: factors leading

[1] The FCLL from this school opened in September 2016 and the person responsible has shown quite some enthusiasm for participating in this study.

to a decision of implementing a FCLL and the use of the FCLL and users' perception of it. Other obtained results are not detailed in this paper.

3.2.1. Factors leading to a decision of implementing a FCLL

The analysis of the factors that led to the decision-making concerning the FCLL implementation was made considering the answers given by the DM and the DMT (13/107) from 12 different FCLL.

According to our data, the principal factor that led the decision makers to implement the FCLL in their school was the *Future Classroom pedagogical approaches* (6) followed by the reason of the schools' *Students with learning difficulties* (3) and the *School philosophy* (2). Two other factors have been pointed out: the *pedagogical needs* (1) and the fact of *Taken part of ITEC Project* (1).

Despite of what 11 decision makers have said that the FCLL of their school is inspired by the Brussels FCL layout[2], only 9 of these are based on the Brussels FCL layout despite having quite some differences. Nevertheless, the identified main reasons for their FCLL being different from the one in Brussels were: the budget (7), the chosen physical space not being the most suitable (6), the School culture (5) and the specificity of the School's students (5). 6 of the 13 decision makers also stated that their FCLL has an area that differs from the Brussels FCL like a playing/gaming area.

3.2.2. The use of the FCLL and users' perception of it

Some questions of the web survey regard the physical and communicative space. The participants (104/107) have an overall positive perception of the initial use of the FCLL; 77% consider the FCLL space to be intuitive (table 1) and 81% think that was easy to identify the different areas (table 2).

Table 1. Perceptions towards the FCLL space being intuitive

	negative perception	neutral perception	positive perception
DMT	20.0%	30.0%	50.0%
T	9.1%	18.2%	72.7%
DMT&T	14.3%	23.8%	61.9%
S	4.8%	14.5%	80.7%
DMT&T&S	6.7%	16.3%	76.9%

[2]The Brussels FCL layout comprises six learning zones in two different spaces: 1) one space based on the traditional classroom furniture setting, the interact learning zone, and 2) the remaining five learning zones (create, present, investigate, exchange and develop) are organized through an open space equipped with different type of technology.

Table 2. Perceptions towards the easiness in identifying the different areas in the FCLL

	negative perception	neutral perception	positive perception
DMT	20.0%	10.0%	70.0%
T	0.0%	18.2%	81.8%
DMT&T	9.5%	14.3%	76.2%
S	4.8%	13.3%	81.9%
DMT&T&S	5.8%	13.5%	80.8%

However, even though 83% think that it was easy to adapt to (table 3) is interesting to notice that 40% of the DMT had a negative perception of it, the exactly same amount for the positive perception stated by them.

Table 3. Perceptions towards the easiness in adapting to use the FCLL space

	negative perception	neutral perception	positive perception
DMT	40.0%	20.0%	40.0%
T	0.0%	18.2%	81.8%
DMT&T	19.0%	19.0%	61.9%
S	4.8%	7.2%	88.0%
DMT&T&S	7.7%	9.6%	82.7%

Nevertheless, only 56% say that there was no need to have an explanation on how to use the FCLL space against 21% of a negative perception (table 4). It is also interesting to notice that when separating S (83/107) from DMT&T (21/107) the values differ in more than 20% for the need to have an explanation on how to use the space – 38% DMT&T against 17% of the S.

Table 4. Perceptions towards the need to have an explanation on how to use the FCLL space

	negative perception	neutral perception	positive perception
DMT	40.0%	30.0%	30.0%
T	36.4%	9.1%	54.5%
DMT&T	38.1%	19.0%	42.9%
S	16.9%	24.1%	59.0%
DMT&T&S	21.2%	23.1%	55.8%

When focusing the questions on the FCLL layout organization towards teaching and learning, the results are in general more alike and positive: when asked about if *in the FCLL it is easy to pass from an activity area to another without disturbing the students/classmates*, we have for positive perception 76% for DMT&T and 67% for S these latter have a slight more positive opinion towards the *spatial FCLL organization allowing them to understand which kind of activity they are about to start* – 73%, despite DMT&T remaining in the same percentage of 76%

when asked if *the spatial FCLL organization allows them to explain which kind of activity they are about to start*. Yet, when questioned if *the spatial FCLL organization is suitable for different kind of activities*, the opinion differ again – 75% of the S had a positive perception of this statement against 95% of the DMT&T.

When the question refers to the *facility of moving the FCLL furniture according to the different activities*, the positive perception presents a decrease to 66% of the S and 81% of the DMT&T. We find a slight difference of the positive perception in which regards the *ease to transform the FCLL layout (furniture displacement)* 68% and 76% (S and DMT&T, namely) and a slight increase of the positive perception to 74% (S) and 86% (DMT&T) when asked about *the activities being enabled by the existing furniture in the FCLL*. In what concerns *the furniture used in the FCLL enabling the teaching improvement and learning improvement* the S and DMT&T's positive perception were akin to the previous one, 66% and 71%, namely, regarding the learning improvement and 72% (S) and 67% (DMT&T) for the other ones. In what regards *the FCLL existing furniture being the most suitable for teaching* the DMT&T positive perception stays at 57% and the S' positive perception in 58%. When questioned about *the FCLL furniture being the most suitable for learning*, the positive perceptions are set in 57% (DMT&T) and 66% (S). Still, when enquired if *the activities were enabled by the FCLL existing layout*, 86% of the DMT&T and 70% of the S had a positive perception.

Some results differ to what concerns *the FCLL layout enabling* 1a) *the teaching improvement* (table 5) and 1b) the *student improvement* (table 6) and to what regards *the FCLL layout being the most suitable* 2a) *for teaching* (table 7) and 2b) *for learning* (table 8). It is worth to notice the difference of positive perceptions not only between the DMT&T and S but also between 1ab) and 2ab).

Table 5. Perceptions on how the FCLL layout enables the teaching improvement

	count	negative perception	neutral perception	positive perception
DMT	10	0.0%	20.0%	80.0%
T	11	0.0%	9.1%	90.9%
DMT&T	21	0.0%	14.3%	85.7%
S	83	2.4%	37.3%	60.2%
DMT&T&S	104	1.9%	32.7%	65.4%

Table 6. Perceptions on how the FCLL layout enables the learning improvement

	count	negative perception	neutral perception	positive perception
DMT	10	0.0%	20.0%	80.0%
T	11	9.1%	18.2%	72.7%
DMT&T	21	4.8%	19.0%	76.2%
S	83	6.0%	27.7%	66.3%
DMT&T&S	104	5.8%	26.0%	68.3%

Table 7. Perceptions on how the FCLL layout is the most suitable for teaching

	count	negative perception	neutral perception	positive perception
DMT	10	0.0%	40.0%	60.0%
T	11	0.0%	27.3%	72.7%
DMT&T	21	0.0%	33.3%	66.7%
S	83	2.4%	37.3%	60.2%
DMT&T&S	104	1.9%	36.5%	61.5%

Table 8. Perceptions on the FCLL layout is the most suitable for learning

	count	negative perception	neutral perception	positive perception
DMT	10	0.0%	30.0%	70.0%
T	11	9.1%	45.5%	45.5%
DMT&T	21	4.8%	38.1%	57.1%
S	83	2.4%	30.1%	67.5%
DMT&T&S	104	2.9%	31.7%	65.4%

A better positive perception (S and DMT&T) regarding the same range of questions but instead of the layout or the furniture, they are questioned about the existing technology in the FCLL, still being noticed a difference between the two groups: *enabling the teaching improvement* the positive perceptions are 77% (S) and 86% (DMT&T); *enabling the learning improvement*, 65% (S) and 76% (DMT&T); t*he activities being enabled by the existing technology in the FCLL* present a positive perception from the S of 70% and from the DMT&T of 86% and it what regards *the FCLL existing technology being the most suitable for teaching* and *for learning* we have, positive perceptions of 70% (S) and 81% (DMT&T) for the teaching. For the learning the S' positive perception is the same however the DMT&T' positive perception decreases for 71%.

Despite the FCLL being designed to allow different spatial configurations in a regular basis, only 42% of the participants (45/107) of the web survey say that *in their FCLL the layout changes*, and from these, 49% is occasionally and 26% once a week to daily; being usually either the teachers (40%) or the students together with the teachers (40%) changing the layout.

3.2.3. Discussion

In general, and from this initial web survey, we may say that the current scenario regarding the FCLL physical space is positive as their users have a positive perception of it. However, from the results, we may infer that the potential of the FCLL physical space is not at its best. Results showed that the options made by the decision makers took into consideration the CSCL and project-based learning approaches present in the Future Classroom project (Van Assche et al. 2015) as

well as a social concern regarding the school's population. Nevertheless, and even if the decision makers have taken into account the families, community, stakeholders, as in a smart learning ecosystem, none of the results support this aspect. Regarding the physical space, its communication and use, results are irregular, particularly if we consider the S and the DMT&T groups separately. Through a HBI perspective, the dialogical relations as well as the users' built environment shaping through interactive opportunities seem not to be completely adjusted as the perceptions users have, despite being positive, present imparities: 77% of the FCLL users state that the space is intuitive, however 56% said that an explanation how to use the space was required; or, the disparities concerning the furniture and the space layout mentioned above. From these results we also might argue that the "balance" between the different space dimensions, and in particular the architectural and the technological ones, is not the most consistent.

Therefore, we argue that an innovative interior design strategy regarding the CPhS and bridging the different presented approaches is in order.

4. Future work

Apart from the analysis of the web survey qualitative data, a correlational statistic regarding these latter is being conducted, in order to gather more grounded information to create the scripts for both the interviews and the workshop/focus group. The participants of these interviews will be key-elements connected to the Portuguese FCLL as its objective is to consolidate some of the data already collected, as well to gather more data regarding the classroom physical space. NEET/Refugee population will participate in the workshop/focus group where they will be asked to design classroom spaces followed by a group discussion.

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