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Capítulo 47.
Smart classroom, an inclusive space to attend to educational diversity

Jordi Mogas Recalde
jordi.mogas@urv.cat

Ramón Palau Martín
ramon.palau@urv.cat

Mònica Sanromà Giménez
monica.sanroma@urv.cat

Jose Luis Lázaro Cantabrana
joseluis.lazaro@urv.cat
Universitat Rovira i Virgili

1. INTRODUCTION

Education and society development are intrinsically connected. Education improves individual and community wellbeing in a sustainable way. International frameworks such as the Agenda 2030 promoted by the United Nations, dealing with the sustainable development, are understood as an opportunity for countries and societies to undertake a path to improve the lives of all. These initiatives do not miss the importance of offering the chance to access to an education of quality. Thus, from the seventeen objectives for the sustainable development included in the Agenda 2030, it is relevant to the fourth one, focused on the need to «ensure inclusive and equitable quality education and promote lifelong learning opportunities for all». This objective goes beyond achieving universal primary enrolment, although the data are alarming: «Over 265 million children are currently out of school and 22% of them are of primary school age» (United Nations, 2019). To accomplish this goal, one of the proposed actions is to promote inclusive education as well as to make learning processes and environments closer to the diversity of learners, overcoming limitations of physical and learning barriers.

Inclusion is a concept not only referred to education, but to any situation in life. Even though, it is in the classrooms where society can tackle with diversity and must educate students to make them have equal opportunities and empower themselves for lifelong learning. But what is expected of the inclusive education? According to Brenes et al. (2018), inclusive education includes the following strategies or approaches:

- Specific support measures being in place to meet individual needs.
- Offer learning and participation opportunities for individuals via differentiated teaching methods in accessible formats.
- Offer assistive devices and required support services.
- Empowerment of all students, particularly those from vulnerable groups like people with learning, developmental or intellectual disabilities.

Definitely, inclusive education is about removing barriers to presence, participation, and achievement in learning, so that all learners can maximise their potential (Booth & Ainscow,

2002). In this sense, it is relevant the universal design for learning (CAST, 2011), an idea detailing how to ensure «that every aspect of the learning environment and teaching and learning processes are accessible to everyone» (Brenes et al., 2018). As these authors clarify, achieving accessible education implies to focus on aspects such as: the physical environment of the schools, communication and language, learning materials, assessment of students, support to individual needs, mobility, commitment to the provision of reasonable accommodations and assistive devices or assistive technologies. From the last ones, it should be noted that the inherent presence of digital technologies in the classroom facilitates the application of the principles of universal design for learning mainly because of the multiple options they provide for flexibility and personalization of learning.

Other authors like Muntaner (2014) establish different options to do the classroom inclusive. For him, the inclusive classroom welcoming all the students and making them participate in the planned activities and situations must accomplish five main ideas: the students must be the protagonists and willing to ask whatever they do not understand, the classroom must show proximity to the students' interests, all the students must be helped in the processes, the method must make the students competent in current society, and the classroom must boost collaboration with common objectives. Therefore, among the characteristics identified in inclusive classrooms, there is a wide range going from broad educative approaches, community and belonging sense, services based on the necessity, teaching adapted to the students, reinforced instructional strategies, and so forth (Dueñas, 2010).

It is clear, then, the need to make the learning spaces inclusive, but some studies show how traditional classroom structures do not facilitate personalization and learning accessibility. According to the research carried out by Arnaiz, Escarbajal & Caballero (2017), the indicator «flexibility and polivalence of the space» appeared to be deficient. In other words, the architectural conditions of the center, the adaptation of the leisure and recreation spaces regarding the needs of all the students and the security measures in the infrastructures for all the students and in particular for those who have special educational needs was reported as insufficient.

Facing the challenges of these needs, the conception of smart learning environments (SLE) and, more concretely, smart classrooms can bring a solution as they are closely related to the aspects identified in the universal design for learning and the inclusive classrooms. SLE are spaces where technology is used in a strategic way to help the student on the learning processes. SLE «must be enriched with digital, adaptive and environmentally aware devices in order to promote faster and better learning», stated Koper (2014).

Such spaces or environments promote technology-enhanced learning initiatives aiming to make more efficient the learning of all the students, with disabilities or not. According to most of the authors, the customisation and personalisation is one of the main potentials of SLE and smart classrooms. But not only: as it is reviewed in the present work, many other characteristics match when it comes to compare smart classrooms and inclusive classrooms with universal design for learning. Therefore, smart classrooms are a good example of inclusive learning space.

In consequence, in this work is reviewed the importance of the smart learning environments and the smart classroom in a way that proves its benefits as an inclusive space where all students have the same opportunities. All students can feel integrated and profit the learning processes in an environment without any sort of barrier. This article firstly shows the objectives and the method. Then, an epigraph of discussion serves to explore the different characteristics of a smart classroom from the perspective of inclusive education. Finally, conclusions are drawn.

2. OBJECTIVES AND METHOD

The main objective of this work is to identify which characteristics of a smart classroom promote inclusion.

The current qualitative approach has been grounded on a previous work (i.e. Palau & Mogas, 2019) where, using a systematic literature review, all the characteristics assigned to smart learning environments and smart classrooms were identified. As a main conclusion, it highlighted the need to consider three different dimensions into a smart classroom: the use of educational technology, the control of the ambient factors as well as the performed processes. These dimensions are concreted with a series of categories and characteristics (see Table 1). This categorisation, as a matter of fact, matches with the idea of making the classroom inclusive and solving different limitations related to students needs, barriers or specific disabilities.

Table 1.Characteristics in a Smart Classroom (Palau & Mogas, 2019)

Dimensions	*Categories*	*Common general characteristics*
Educational Technology	Hardware and physical technology	Mobile devices, touch screens, interactive tools, whiteboards and others, sensors, tracking systems like eye-movement or recognition systems, cameras, RFID.
	Software	Software, LMS, smart learning platform other than LMS, GPS.
	ICT and New paradigms	Internet and cloud computing, big data and learning analytics, Internet of Things, artificial intelligence, augmented reality, virtual reality or immersive worlds, social media.
	Features or attributes for educational technology	Feedback or assessment, adaptivity and awareness, ease of use, integration.
Physical ambient conditions	Architecture	Functional design of the space or classroom, equipment.
	Environmental factors	Temperature, humidity, lighting, air quality (oxygen / CO2 / smell), noise or echo, electricity consumption or production.
Performed Processes	Learning content	Content, resources and tools, activities.
	Processes performed by actors (learners, teachers, parents)	Different approaches to the pedagogy and educational processes, collaboration and cooperation of students, experimentation, problem based and learning by doing, constructivist pedagogy.
	Processes and features helped by the system	Personalization and customisation, engagement and motivation, effectiveness and efficiency, connectedness and community, self-regulation and autonomy, interaction, contextualisation or context of use, tracking or monitoring learning, automation.

Therefore, this general characterisation of a smart classroom is retrieved to identify which are the characteristics that actually make it inclusive. The main ideas and some examples are proposed below.

3. DISCUSSION

Different studies have proven the importance of the smart classroom to cope with challenges as inclusion and educational diversity. In this sense, Sardinha, Almeida & Pedro (2017) presented «an ongoing research that intends to define and investigate the role of innovative interior design strategies to create inclusive classroom spaces». Christensen, Rodil & Rehm (2017) reviewed studies and researches «based on the design and development of technical solutions for people with autism, learning disabilities and special needs» to complete their work on smart learning environments. In addition, Bakken, Uskov, Penumatsa & Doddapaneni (2016) deal in depth with «Smart Universities, Smart Classrooms and Students with Disabilities». These examples indicate that smart classrooms, even being an emerging concept still lacked of scientific consensus to be unequivocally defined, are already being considered potential spaces to promote inclusion; this is, they can be seen as inclusive classrooms.

According to previous work (Palau & Mogas, 2019), smart classrooms are defined by a series of characteristics and almost always understood as spaces where customisation of the learning must happen. Personalisation and customisation are in fact the most recurrent characterisation of a smart learning environment or a smart classroom: it is the most referred characteristic among all the identified ones, indeed. Also Freigang, Schlenker & Köhler (2018) locate the learners' needs in the core of their referential smart learning environments framework, consisting of two dimensions, each one counting three categories. As the authors state: «modern digital education formats must be aligned to a learners' individual needs».

In other studies, it is described the different types of students with disabilities that can take advantage of a smart classroom. Bakken, Uskov, Penumatsa & Doddapaneni (2016) specify learning disabilities in general, speech or language impairments, visual impairments and hearing impairments. All these disabilities can find solutions within the smart classrooms and, as a conclusion, the authors add the following points:

- Smart classroom can significantly benefit students with disabilities even though they are not the focus.

- Many technologies geared towards students without disabilities in smart classroom will actually impact the learning of students with disabilities.

- Some students with disabilities may need specialized technology to be successful.

- Some technologies focusing on the success of students with disabilities may help students without disabilities to be successful.

Other researches specify more concretely the customisation and personalisation performed in a smart classroom to achieve better and faster learning in cases of disabilities. For instance, the use of voice recognition systems (Uskov, Bakken & Pandey, 2015), improved in Uskov et al. (2018) where it is explained how to automate the functions of a smart university in order to adapt the context to the needs of students with disabilities. With this purpose, they use softwares including voice-to-text (voice recognition) systems, text-to-voice (voice synthesis) systems, and gesture and motion recognition systems.

Based on previous research and from what it has been observed, following this discussion, it is added a complete characterisation of the smart classrooms according to the three dimensions previously identified (educational technology, ambient conditions and performed processes) and their categories. Always from the point of view of the inclusive classroom.

Dimension 1: Educational Technology

The three dimensions of a smart classroom must coexist, which means that different characteristics of every dimension will be present at the same time. It is even necessary to consider the fact that some of the characteristics are placed in a category or dimension, but inner relationships are obvious and natural, making some characteristics to depend on some others.

In the case of educational technology, four categories were identified grouping the characteristics. The first one stands for hardware and physical technology, referred to the devices in a broad sense; secondly, there is need to consider the software installed in the devices (including the learning management systems); thirdly, ICT and new paradigms will be reviewed at a general glance; lastly, there is a category devoted to state the features and attributes to consider when talking about educational technology. In table 2, a concrete overview of these categories in relation to the inclusive classrooms is exposed.

Table 2.Inclusion potentiality of smart classrooms: Educational Technology dimension

Categories	*Potentiality in Inclusive Education*
Hardware and physical technology	In this category are included diverse characteristics related to the physical technology. They are closely related to other dimensions. As a technology, the devices must allow accessibility to all the disabled students, they must manage and use all kinds of devices included in a smart classroom. The discrimination or restriction can be from physical barriers or when the hardware has its own restrictions. In the first case, the solutions could come from the elimination of all the physical barriers in the classrooms. In the second case, the system should assure that all the devices used in the classroom have their own policy of accessibility. Examples of this can be seen when the interactive whiteboard is in a stage and a student moved using wheelchair can't use it, or when this device is in the height of the teacher and the student of wheelchair can't reach it. For this problem, in a smart classroom the stage should be eliminated and a mobile interactive whiteboard must be installed to allow adjustment of the height to the needs of the student. To guarantee inclusion, touchscreens and interactive tools can be introduced in a smart classroom, but considering every single individual interacting in the space. Thus, these technologies could help *per se* if introduced using the right teaching methodologies, otherwise new limitations may come up. Nowadays, it is still too early to state that cutting edge technology like sensors, eye-movement tracking systems or facial recognition systems, make the smart classroom inclusive. Not even can be said that such technologies contribute to gain higher integration thanks to a response to the learning and actions data gathering with individualised feedback provision. This sort of characteristics are in an exploratory stage and consistent evidences are not presented yet. Nevertheless, it is advisable to bear in mind this tendency of progression since technological advances are likely to continue in this line.

Categories	Potentiality in Inclusive Education
Software	During the last years, software has been a topic with big advances, mainly focused on vision and hearing difficulties. Even so, software is still currently a field where the students with special needs can find obstacles. In a smart classroom it is important to provide the most suitable softwares to ensure the quality of learning. The authors usually refer to learning management systems (LMS) or other types of platform with the aim to support learning and to make it more efficient. In a smart classroom, this software is a complement that makes the face-to-face learning more interactive and personalised, with features such as tracking of the progression for every individual. Therefore, students with disabilities or problems can specially benefit from these systems. To give an example, a traditional lecture would advance following the rhythm established by the teacher, whereas in a smart classroom the teacher will take inputs from the software being aware of the personal learning needs from each of the students.
ICT and New paradigms	The category of information and communication technologies and new technological paradigms shows trends on how advances can influence positively education and be introduced into the smart classroom to make it more suitable for a better and faster learning. However, it is not clear how it is being used in an efficient way. Concepts as internet of things and artificial intelligence are reported as elements to be considered in the smart classroom, with no evidence of their impact, by now. In consequence, we can suppose a positive effect for the inclusive classroom but further research is needed in the field.
Features or attributes for educational technology	Listed as a differentiated attribute, the category related to the general features expected from the educational technology is one of the most relevant in this study. Most of the studies retrieved on the systematic literature review to characterise the smart classrooms point at feedback and/or assessment as an elementary feature of the system. In other words, a classroom to be smart needs to provide some output as a response to the student's actions. With no feedback for the student, the classroom could hardly ever be considered smart. And this is connected directly with the inclusion: if an inclusive classroom looks for attending the educational diversity and to ensure all the students can participate in the process with equal chances, then assessment and feedback are necessary. Adaptativity and context awareness are also typical features attributed to smart classrooms, since a main difference between traditional classrooms and the smart ones lies in the fact that the latter cares about the context where the learning is being acquired, and can either modify the system or provide insights to the teachers to make them capable to take the most convenient decisions. To give an example, if something happens outdoors becoming a distraction for some of the students, the teacher might not be aware and keep on the lecture or activity. If the smart classroom identifies the problem and alerts the teacher, the situation can be more easily straighten. In case there is some student with disability, special needs or no matter which kind of educational attentional need, the smart classroom can ease the adaptation of the learning processes and activities held at class. Ease of use is also referred to characterise smart learning environments and smart classrooms. Not only with specific aims of inclusion, but a smart classroom must include educational technology easy to use, avoiding students to spend time with technological adaptation instead of learning the needed content.

Dimension 2: Physical ambient conditions

The physical ambient conditions are defined by the architecture and the environmental factors of a smart classroom. From this dimension, the most relevant category in relation to the inclusive classroom is the architecture, aiming to ensure the physical accessibility and to avoid architectonic barriers. The environmental factors can also have certain impact as explained in Table 3.

Table 3.Inclusion potentiality of smart classrooms: Physical ambient conditions dimension

Categories	Potentiality in Inclusive Education

Categories	Potentiality in Inclusive Education
Architecture	The architecture of a smart classroom is basic to promote a better learning. Approaching it, the universal design for learning and the suppression of physical barriers are aspects to take into account for a good design of the space. Many projects during the last decade have been working on learning spaces design. Some of them focused on the alignment or the adaptation of the classrooms to the needs from the new methodologies or revisions of active methodologies appeared in the educational market. All of them have some characteristics in common. Firstly, the flexibility and, secondly, the adaptation of the students. Both of them could be referred to inclusive education, although the latter with special and direct affectations. When talking about an adaptation of the students, the idea is connected to all type of students. Recently, it is mentioned that methodology is the first tool or way to attend the needs of students, but active methodologies need flexible spaces. The solutions could come from the elimination of all the physical barriers in the classrooms and to refurbish with furniture and equipment taking it in consideration. Thus, the design of a smart classroom have to guarantee the accessibility to all people, as well as the contained furniture of the space.
Environmental factors	Two characteristics can be highlighted in the category of environmental factors: Light and sound. The former because vision difficulties can be affected or solved by the quality and quantity of light. The latter because the sound and the noise can be reduced or augmented with technology and materials. Different experiences have already shown the importance of lighting in the learning spaces. Lighting must consider artificial and natural light, the intensity and the colour of light, the reflections on the screens, etc. Some studies have developed smart systems to adapt the lighting to the processes happening into the classroom. There is need to consider possible cases of students with visual dysfunctions in order to make the smart classroom inclusive. Depending on the type of activities and the needs of the students, the chance to regulate the sound can also have a direct impact on the learning. Sound can more concretely be referred both to noises (external noises, distracting noises, and so on) or to echo (if the acoustics of the classroom is not appropriate). Teachers in a smart classroom should owe a system allowing them to regulate the sound, with special attention in cases of auditory dysfunctions. Temperature and humidity are also factors that affect the learning and ideally should be automatically regulated by the system, in a smart classroom.

Dimension 3: Performed Processes

The third interrelated dimension defines the performed processes in a smart classroom. As it is explained in Table 4, all the processes happening in the classroom have an impact on the learning. There are not ideal solutions, but a smart and inclusive classroom must consider this conceptualisation to fulfil its principles.

Table 4.Inclusion potentiality of smart classrooms: Performed Processes dimension

Categories	Potentiality in Inclusive Education
Learning content	From the point of view of the content or resources, there are many options to attend inclusive education. Students with different learning styles, different learning rhythms, different interests and different needs should have different resources and activities. The smart classroom is prepared to solve these differences and, by definition, watches over the need of providing the adequate contents and resources. It is often the responsibility of the teacher, but the space must be aware of the processes as well, with recordings or providing insights.
Processes performed by actors (learners, teachers, parents)	The process of teaching and learning is a human process, although nowadays it is covered by technology. This way learners, teachers and parents are the main actors in the process. Smart classrooms can provide them information in real time that allows them to take decisions and to give answer as fast as possible. This information and these answers are especially important in students with special needs. Different authors introduce collaboration and cooperation of students, experimentation, problem based learning and learning by doing as the most trending processes performed by the students.

Categories	Potentiality in Inclusive Education
Processes and features helped by the system	When the system can provide help or feedback, it can be a way to give attention, answers and solutions to the students. Personalization and customisation is essential in smart classrooms. Above, it was highlighted the feedback and/or assessment characteristic, which is closely related to personalisation, and as a consequence it brings up parallel justification. It is notable the importance of personalising the education intending to do the classroom inclusive. Engagement and motivation are also necessary, and the smart classroom must provide resources to collaborate. The field of psychology has proven the correlation between motivation and effectiveness of the learning. Not only for students with special needs, emotions play a key role to encourage learners and make learning more efficient. Thus, a smart classroom counts on this feature that would affect in inclusion as well. There are other characteristics linked to the processes and features helped by the system, making evident the relationship between smart classrooms and inclusive education.

3. CONCLUSIONS

The main objective of this work has been achieved. Throughout the review of different theoretical references, as well as discussing the categories and characteristics of a smart classroom, it has been highlighted how the educational diversity, inclusion and the needs of all learners can be attended. Previous works had already explored the smart classroom as a space to deal with students with disabilities (e.g. Bakken, Uskov, Penumatsa & Doddapaneni, 2016), and here it has been exposed a broader comprehension of the possibilities.

As a matter of fact, it is important to insist that smart classrooms are not usually a space devoted to attend educational diversity and students with disabilities or special needs. Even though, as some authors state (e.g. Bakken, Uskov, Penumatsa & Doddapaneni, 2016), these people can profit the advantages of a smart classroom because any student can find benefits for a better and faster learning. In fact, some of the processes will occur induced by the agents involved in the action (they are responsible for the success), whereas others may happen thanks to the defined smart classrooms in favor of all the people involved. From another perspective, the inclusion can bring benefits not only to the students with special learning needs but to the whole group, based on the concept of «educative potential of the heterogeneity» (Pujolàs, 2012).

The three dimensions of a smart classroom have to be combined and no dimension should be dismissed (Palau & Mogas, 2019). Educational technology appears basic since technology can be used in an integrative way in a broad sense. The performed processes are essential, and so it is important to ensure the adaptation to the situations for both, to fulfil the requirements of a smart classroom and to give answers to the specific needs. Finally, the environmental factors also matter when it comes to define a smart classroom as an inclusive space, in particular featuring the architectural design to ensure accessibility is elemental, an idea closely related to the universal design for learning and to avoid learning physical barriers. Physical barriers are, in fact, treated by Booth & Ainscow (2002) as all what limits the inclusive possibilities in the classrooms and in the centers: the educational culture, the currículum flexibility, the characterisation of the spaces, the inner organisation of the center, etc.

Finally, it is necessary to assume that smart learning environments and smart classrooms in particular are being increasingly studied and defined, but there is not a unique definition or a referential framework to work with. Some studies aiming to solve this lack in the literature are appearing, but the novelty of this complex sort of space design, with different dimensions, could be seen as a limitation in general when dealing with smart classrooms. Therefore, the present study is scientifically well grounded on previous work, but still would be necessary further empirical research to compare and define better the impact of the smart classroom's characteristics on educational diversity and students with special needs. Future research lines could explore in depth specific points of the conceptualisation here explained.

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