Design FILS

Designing Future Innovative Learning Spaces

Methodological Framework for Innovative Classroom Trainings

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Information

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Abstract

Often stereotyped**,** traditional teaching is characterized by a pedagogical delivery model taking place in a standardized and fixed classroom. Current teaching practices show that many teachers want to shift to a different paradigm with less pedagogical sameness, facilitating personalized, student-centered and active learning, while aiming at building future skills. In this study, the different parameters are explored to bring active learning into practice. The physical design of the space as well as the use of educational technology are critical components that support active learning pedagogy. The academic literature on the three pillars of active learning – pedagogy, space design and technology – forms the theoretical and methodological basis to define strategies and recommendations on the key aspects of teaching in future innovative learning spaces.

Keywords: active learning pedagogy, learning space design, educational technology

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Contents

Methodological Framework for Innovative Classroom Trainings

The world is changing rapidly. Global expectations for education systems are increasingly ambitious. The physical classroom space has come to matter in policy which aspires to meet the needs of learners in the twenty-first century. Classrooms or the learning space are thought of as a change agent which could lead to innovation in practice and a substantial positive change at the classroom, school and education system level. However, learning spaces are a deeply nuanced field and the result of interrelations between a range of other fields and materially-embedded practices within pedagogy. The learning space is connected to a wider context of pedagogical ideas and theory of learning, space design, and technologies.

The ways in which space constitutes human activity are well known (e.g. Hall, 1966). Although advances in related work developed in anthropology, and even psychology, are systematically ignored while designing learning spaces in schools. For more than 200 years, the traditional configuration of a classroom has been more or less the same, it adopts a geometry-based pattern designed to give every student the possibility to see the teacher and the blackboard. This kind of space organization encapsulates the conceptual metaphor 'understanding is seeing' as referred to by Lakoff and Johnson (1999). This traditional form of organizing the space is still prevalent in most classrooms around the world today. The physical space is designed on an audience-based format – in fact derived from the Latin *auditĭo* – assuming as a principle that the class (the audience) should seat and 'hear 'the teacher. No one knows exactly how to prevent learning-loss when designing a classroom pedagogically, whereas we know quite well how to design for minimum heat loss.

However, learning environments are undergoing a rapid change with the impact of digital technologies on teaching and learning. The importance of creating learner-centred, collaborative and social, motivating, individualised, and challenging learning environments, which are supported by formative assessment was highlighted in a number of policy documents (OECD, 2015). There is no 'one-size-fits-all' solution to creating such an environment. Innovation in learning spaces should be responsive to local needs, embedded in local contexts and environments, and should be a continuously adapting process based on the needs of teachers and students.

The very concept of learning spaces must be the focus of innovative approaches to schooling. The social practice of teaching and learning is inherently associated to identity, ownership and agency in relation to use of space and time – space being in general the drive force that

formats schooling timings. The effort to design innovative and stimulating learning spaces relies on the premise that it is crucial to human activity at all levels – physical, cognitive, affective.

Intentions of the document. The present document aims to provide a theoretical and methodological ground for the Future Innovative Learning Space Design Project. It draws on recent literature in the area exploring how to develop and adapt learning spaces in order to enable innovative technology-enhanced pedagogies. It also brings together a multi-disciplinary team (teachers, teacher educators, architects) to engage in conceptual understanding of the key terms, and draw on their expertise. The theoretical and methodological framework is based on three key pillars to build a learning environment for the 21st century: Space Design, Pedagogy and Technology:

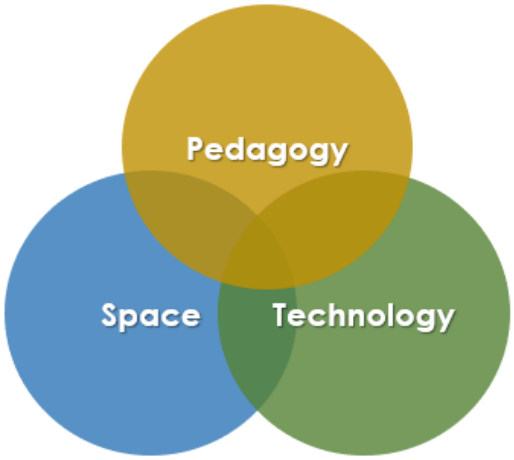

Figure 1. Three Pillars (Steelcase Education, 2014)

Chapter 1 discusses the affordances of learning spaces – the opportunities for learning provided by space design. It emphasises not only the architectural and technological aspects of space design, but importantly pedagogical. It presents a framework of special typologies including key elements, principles and strategies in space design to support student-centred pedagogy.

Chapter 2 investigates the key dimension in space design – pedagogy. It aims to clarify the key concept of innovative pedagogy and examines innovative teaching and learning practices that should assist in developing the so-called 21st century learning skills in students. In essence, it presents a number of pedagogical approaches, also supported by technology-rich environments.

Chapter 3 considers the role of technology in education, and key principles to integrate technology in teaching and learning.

Chapter 4 concludes with strategies and recommendations for implementing innovative pedagogy in schools and the integration of technology-enhanced space into teaching and learning. These are considered at four levels: system and policy level, teacher education, school level, and classroom level.

Chapter 1: Space design

Theoretical background

In policy and practice, there has been an increasing interest in re-consideration of learning and the spaces where learning takes place. The notion of *innovative learning spaces* has emerged in response to the influx of educational technologies and new social practices associated with 21st-century teaching and learning (Carvalho & Yeoman, 2018). In education, the focus has shifted more and more to helping students develop a way of thinking, a way of working and a way of living together. Conceptually, there has been a move away from traditional teacher-directed space, the *classroom,* to a more student-centered space, simply a *learning space* (Duffy & Tobias, 2009; Woodman, 2016).

The key argument here is that design of a learning space is closely linked to teaching and learning practice (Horne-Martin, 2002; Sigurðardóttir & Hjartarson, 2011). Indeed, the character of the learning space changes with changes in its practice. Modern classrooms have been reconstructed, with good reason, to reflect learner-centred environments, collaboration, self-directed learning, inquiry, exploration, creation, active learning, and relationship building, allowing more creativity and flexibility (Sheninger & Murray, 2017*)*. In this regard, the teacher's role progresses from being a 'sage on the stage' to being a 'guide on the side'. Instead of a dispensation of facts, a class session becomes a participatory gathering of facts (McDonough, 2000).

Such a change in roles and shift in focus requires a change in the space. There is a need for teaching spaces that enable a learner-centric culture, and engage teachers creatively with their development to meet the changing demands of societies and the educational curricula (Campbell, 2020).

Furthermore, studies suggest that configurations of space for teaching and learning are indirectly causal of human behaviour within them, influencing choices and experiences within the space (Brooks, 2012; Tondeur et al. 2017). Space - whether physical or virtual, individual or shared – can have an important impact on learning and teaching. When designed in consideration of teaching and learning, specifically the type of activities needed to achieve learning objectives, a space becomes a third teacher. Space can encourage the feeling of togetherness, exploration, collaboration, discussion and reflection. Space is a constitutive part of teaching and learning. As well as learning spaces are constituted in temporal and pedagogical processes, they are constituted through action.

Therefore, the present chapter draws on a need to address the issue of architectural choices not so much in their technical and aesthetic aspect, but from a pedagogical perspective. It aims to learn from the existing evidence in the field. First, it looks at a number of key projects that aim to design innovative learning spaces, and their key outcomes. Next, the chapter presents the typology for space design and the principles to be considered in design of innovative learning spaces (both physical and virtual). Finally, it concludes with connecting space design and pedagogy by drawing from literature around space design to support teaching and learning.

Approaches to space design in European research projects

One prominent approach "*The Future Classroom Lab (FCL) project*" created by the European Schoolnet (EUN) in 2012. Its aim was to act as a 'living lab' mainstreaming innovative practices in schools and helping visualize how conventional classrooms and other learning spaces can be reorganized to support changing styles of teaching and learning. The FCL aims to be an inspirational learning environment, challenging visitors to rethink the role of pedagogy, technology and design in their learning space (Attewell, 2019).

The project suggests that setting up innovative learning spaces can pursue a number of goals (Attewell, 2019, p.12): to meet the needs and expectations to develop 21st-century skills; to use modern technologies and experiment with different pedagogical approaches; to enable teachers to enter a room where everything works so they can start immediately; to change teachers' mind-sets by providing a space where they can reflect on their current practice and be motivated to start experimenting with new methods and tools; to demonstrate how different teaching and learning styles can be generated by reorganising the learning spaces and incorporating technology; to increase the effectiveness of teaching by focusing on the learner rather than lessons being centred around the teacher; and to support and enable changes in pedagogy.

To enhance the space design and support the 21st century teaching and learning, the FCL is compiled of six different learning zones (see Figure 2) where students can accomplish the following tasks/activities (Bannister, 2017):

- Create: students are encouraged to plan, design and produce their own work.
- Interact: learning involves both teachers' and students' active engagement.
- Present: sharing of students' work is important to learn to share and communicate, interact with a wider audience, and develop feedback skills.
- Investigate: students are encouraged to be active participants and discover for themselves.

- Exchange: teamwork, peer-to-peer collaboration takes place while investigating, creating and presenting.
- Develop: a space for informal learning and self-reflection.

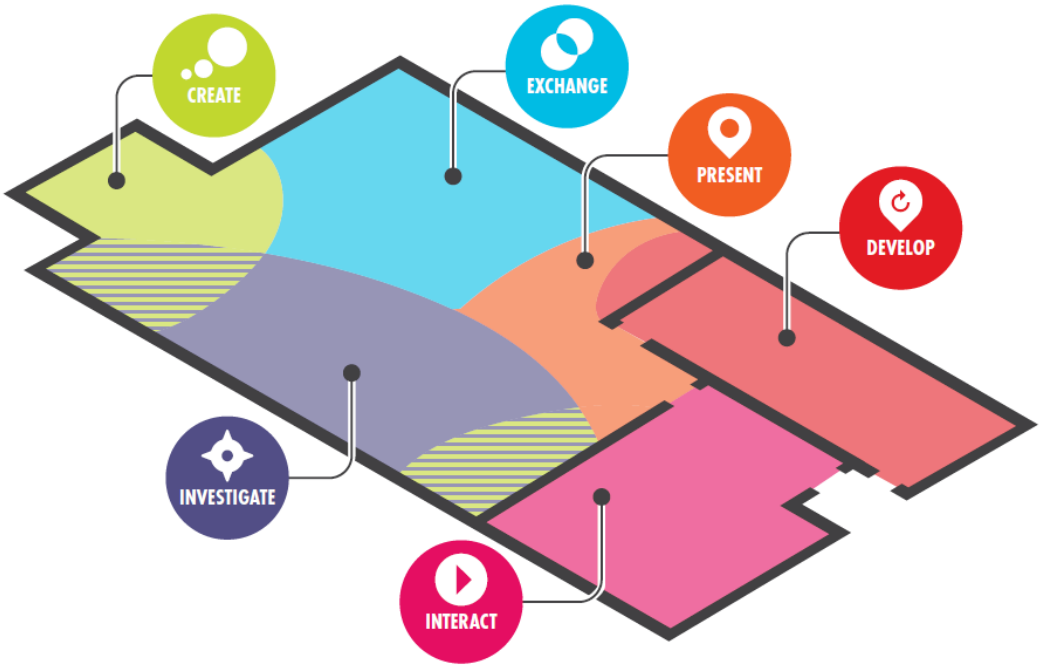

Figure 2: FCL Learning Zones (European Schoolnet)

Collectively, the learning zones provide a way to think about how different, innovative pedagogical approaches that incorporate ICT can be implemented in the classroom. Each learning zone represents a pedagogical concept. The design of the six learning zones helps enhance flexibility, and supports active learning pedagogy. It aims to improve and facilitate our students' learning both for small groups where learners could discuss, plan, create, and brainstorm; for large groups, learners get instruction and presentation opportunities; for team and individual work. It represents a space for practice and reflection. The FCL has technology-rich areas for activities such as online research, virtual communication, media production, and app development. It includes quiet, solitary areas for individual reading, writing, and reflection as well as makerspaces where learners have access to technology as well as hands-on materials (Basye et al, 2015).

Importantly, the teacher needs to design tasks which encourage different learners to take responsibility for various aspects of the activities (Bannister, 2017, p.19). To support and inspire teachers, within the FCL Project, learning scenarios and learning activities were developed and the approach has been further used in a number of projects.

Next, the *Eduspaces21* Project funded by the European Union (EU) Program in 2016 aims to support schools in the design of educational spaces with the 21st-century solutions in mind. The project comprises three principal dimensions and aims to provide guidance and solution in each: *physical space* (architecture, equipment, school infrastructure), *virtual space and technology* (online/ network-based learning and teaching), and *social aspects* (school community, local community, contact with the world).

The project distinguishes a number of key principles for space design – important for each dimension. For physical space, flexibility and connection that allows to adapt space to the changing conditions and tasks and connect various educational spaces into one learning environment is important. Space should also consider social dimensions and contribute to inclusion, co-operation, and creativity. It should be inspiring and supportive of efficient teaching and learning.

Another interesting research study "Clever Classrooms" (Barrett et al., 2015) was carried out in the UK within the Holistic Evidence and Design (HEAD) Project. The study focused on the impact in which a learning space has on student learning. The project team developed and distinguished three broad categories of design elements: 'naturalness' which encompasses the light, sound, temperature, air quality, and links to nature; '*individualization*' (a category of flexibility and ownership address how well the classroom is adapted to the learner's needs); and 'stimulation' (colour and complexity which represents the degree of visual stimulation) in learning spaces. The report concludes that well-designed learning spaces that consider the three elements boost learner's academic performance such as reading, writing and maths.

To conclude, important characteristics for space configuration were considered here through a number of European projects in the area of Space Design. Some focus on the architectural and aesthetic aspects of space design (such as Clever Classroom Project), some on technology-enhanced pedagogy (such as FCL and EDUSPACE21). Crucially, space design is seen as a complex process through which more elements need to be considered. Next, a comprehensive literature review looks at the typologies of space design and key principles in designing innovative learning spaces.

Typologies of Space design

The learning space our students inhabit is a fundamental element in the teaching and learning process and its design must be informed by the institutional culture, pedagogy and curriculum, and the necessity to interact with the external world, in particular through digital technology.

Flexibility is a core component of the learning space, in regard to how the teachers can utilize the space and to time. It should consider the needs of learners and the specific pedagogical approaches chosen by teachers. As Long and Ehrmann (2005, p.46) suggest a space should support the activities for effective learning: "that is, situated, collaborative, and active learning". Therefore, the learning space should not only foster interaction, collaboration and communication among learners but also give them the opportunity to have some time to research, investigate, read and gather information individually. Basye et al. (2015) argue that learning spaces should also accommodate virtual learning experiences, multi-age learners, long-term project work, and students using a variety of devices. Furthermore, spaces must be inclusive for students with special needs.

The right technology needs to be incorporated into the space design, so it can be accessible to students as well. Basye et al. (2015) argue that designers of innovative learning spaces are challenged to provide learners with the necessary access to technologies that motivate and engage them. In fact, spaces should support the use of analogue and digital tools. The 21st century learning requires spaces that connect school, home and community, and support learning outside the boundaries of a classroom and even the school building itself.

Important is an understanding that the design of learning spaces per se does not contribute to the magnitude changes hoped for. First, there needs to be a clear idea of what activities learners need to accomplish, and space should be adapted in consonance. Second, space design is an important issue that affects learners' emotional, cognitive and behavioural engagements (Fredricks, Blumenfeld & Paris, 2004; Cleveland, 2016). In this sense, space design has a huge effect on learning, potentially with positive or negative effects on learners' psychological and physical perceptions, and these needs to be considered in space design.

Indeed, any environment acts on a learner's senses in different ways. People see forms and colours with light, they smell and feel the surfaces, materials, hear the sound of spaces, sense the warmth or coolness of the different colours, form, patterns or materials. Aesthetically and ergonomically pleasing environments support positive teaching and learning experiences. Comfort, as well, is a crucial precondition for successful learning. On the other hand, the teaching-learning processes and success are linked to a learner's concentration time and his/her ability to focus. Whether the design of a space is perceived as interesting, pleasant, meaningful, rigid, lively, relaxed, or dynamic seems to be primarily determined by *the sense of ownership and belonging*, *the degree of flexibility and complexity of space design – influenced by the degree of stimulation of the senses*.

Next, the core principles for design of innovative learning spaces (physical spaces) are considered in more detail.

Basic principles in an innovative learning space design (physical space)

When designing an innovative learning space, first, it is necessary to pay attention to three principles. These are:

- *Flexibility* (layout, arrangements)
- *Ownership* (place attachment, identity)
- *Complexity* (level of colour, layout, furniture and equipment)

Flexibility (layout and arrangements)

Flexibility is the ability to be easily modified to different needs in the short term, for instance; adjustable furniture or equipment, which can perform a number of functions, or folding partitions that can be moved to create two or more spaces. The learning space needs to be effective in multiple configurations to meet the diverse spatial needs for teaching and learning activities such as team teaching or small group work among other variations.

Monahan (2002) indicated that flexibility with five supportive properties to provide a dynamic space; *fluidity* as representing the design of space for flows of individuals, sight, sound, and air, *versatility* as indicating the property of space that allows for multiple uses, *convertibility* as designating the ease of adapting educational space for new uses, *scalability* as describing a property of space for expansion or contraction, and *modifiability* as the spatial property that invites active manipulation and appropriation (Wulsin, 2013).

The layout of a space can be a challenge to rearrange when different teachers are using the same space, but with a flexible arrangement of furniture and equipment, learning spaces can help learners and teachers to acquire collaboration, teamwork, and other interpersonal skills. Furthermore, a learning space needs to consider furniture at different heights to encourage learners to move, but also to provide space for their individual needs, such as wheelchair access (Bannister, 2017). Thus, flexibility is a key design requirement.

Ownership (place attachment and identity)

Ownership can be identified as place attachment and identity. Barrett et al. (2019) have stated that ownership is related to how much the room is organized for both the learning space as a whole and each learner.

According to the reports of Barrett et al. (2015, 2019) a learning space that includes learner-created works are more likely to provide a sense of ownership. Good quality, learner-centric furniture, fixtures, and equipment can be used to strongly support learning and indicate that learners are valued. Distinct design characteristics (i.e. class-made artwork), personalized

storages (i.e. personally named storages), and high-quality chairs and desks foster a sense of ownership and provide identity among learners. Thus, when learners feel ownership of the space, the feelings of responsibility appear, and intellectual engagements and projects are promoted more participation and involvement in the learning process (DeVries & Zan, 1994; Ulrich, 2004; Barrett et al., 2015).

Complexity (crowding–density)

It has been suggested that focused attention is crucially important for learning, and visual features in a learning space effect especially younger learners. However, complexity is a measure of combining the different elements: how they are organized, the rate of usable information of a space, and the rate of the noticeable differences (Akalin et al., 2009, Barrett et al., 2015b). Rapoport (1990) stated that the noticeable differences between the perceived number of elements provide a level of visual complexity. Berlyne (1960) mentions that the formal complexity of space is affected by the number of details, diversity, novelty, and the level of used elements (grouping larger units decrease the complexity). According to the studies, learning ability and perception occur at an *intermediate level of complexity* but decrease at the high or low extremes of complexity (e.g. Berlyne, 1974, Akalin et al., 2009, Fisher et al., 2014; Barrett et al., 2015b).

In this sense, Barrett et al. (2019) mentioned that visual variety in the room layout, ceiling, and display, in balance with the use of displays, create interest but with a certain degree of order. Light coloured walls in combination with a feature wall or areas highlighted with a brighter colour produce an optimal level of complexity and stimulation. Another option is to use bright colours on furniture as accents to the overall environment. Colour affects the complexity level, but the use of more than three colours can make the space more complicated.

Thus, the degree of visual diversity of spatial arrangements (i.e. furniture, student work) and surface (wall, floor, ceiling) should be balanced. Fisher et al. (2014) stated that learning scores were higher in the sparse classrooms than in decorated classrooms. Therefore, attention needs to be paid not to exaggerate with decorations and colours.

To conclude, the spatial conditions that should be considered for human well-being and learning include seven indicators: colour, lighting, furniture, acoustics (Walden, 2015), indoor environmental quality (IEQ) as heating- cooling-ventilation, materials, and spatial arrangements of all these elements. Together they affect productivity, concentration and engagement (as illustrated in Figure 3), and significantly influence the sense of well-being and learning performance.

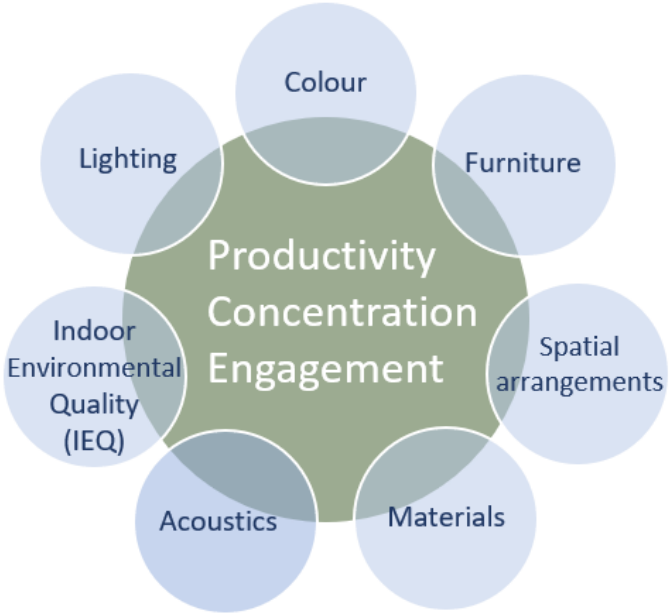

Figure 3: Seven indicators of a learning space effect teaching-learning performance & productivity, concentration, and engagement.

Importantly, a space does not affect all learners in the same way. The challenge is to make it an acceptable space for everybody. Each element is a crucial part of a visual message, and the combination of these elements have an impact on perception which affects motivation. Design elements can be used alone or in combination with each other considering design principles depending on what is wanted to achieve.

Below is a summary of key elements to consider in design of a physical innovative learning space with their importance for innovative teaching and learning.

Elements in Space Design	Reason	Suggested solutions
Spatial arrangement	To consider the learners' needs, chosen pedagogical approaches, possible teaching and learning activities, and the structures of the curriculum and the timetable	Flexible learning spaces that can be easily reconfigured according to the needs of different learning activities; Well-designed circulation inside the learning space to allow for easy repositioning of learners and teachers; Diversity in the learning space allows learners to better adapt to the environment in accordance with individual differences (i.e. some young learners are not capable of sitting in front of a *table* for a long time at *chairs* but they can manage better to study on the floor/carpet) (Polak, 2016, p.20).
Colour	• to create a psychologically pleasant atmosphere and mood; • to increase concentration, engagement and productivity; • to highlight different areas/zones in the learning space	Soft colours; Differentiating the walls, floor, and ceiling with colour to break the monotony and visually stimulate learners (Polak, 2016);
Lightning (natural and artificial)	For bodily and mental well-being	The direction of natural light needs to be distributed optimally in the classrooms, by means of direct or diffuse light (Polak, 2016); To consider the warmth of artificial light
Furniture and Equipment	• to promote flexibility and mobility; • to promote comfort, safety, and psychological needs like motivation and concentrations; • to eliminate static postures.	Flexible furniture that accommodates the arrangement of learning zones in the space: • chairs with flexible chair backs and adjustable seat height (Cornell, 2002); • comfortable and ergonomic chairs; • adjustable-height tables/desks for multiple uses (writing, computer use, drawing and collaborative activities); The number and size of storage to consider not to impede circulation; can be equipped with wheels and used as convenient space dividers (Walden, 2015)

Materials	To consider elasticity, noise generation, electrostatic behaviour	The more natural materials the better we feel in learning environments
Indoor Environmental Quality	For well-being and comfort; To ensure the quality of air	The design of the windows is significant in terms of climate conditions and geographical orientation (Polak, 2016); Free use of windows to regulate the temperature; or when the window cannot be opened, air circulation is usually provided utilizing mechanical ventilation with heat recovery. In this way, 70-80% of the inside air is replaced in the building every hour, which means that the pupils and teachers are constantly provided with fresh and clean air in the learning space (Polak, 2016).
Acoustics	To consider auditory factors in space design	Use of noise-absorbing materials (i.e. carpet, textiles, acoustic panels, or fabric-covered boards) (Walden, 2015; Polak 2016).

Virtual educational space

As mentioned before, teaching and learning in the 21st century has the potential to, and does in many places go beyond the school building and conventional school timetable. Thanks to development of the Internet and other new technologies, new possibilities have opened for learning, and the virtual space has become an extension of the physical classroom space.

Virtual spaces are created when technology provides a bridge between learners and a newly conceived world of information – that is perceived as both remote and immediate. The key feature of the virtual space is its fluidity and dynamic nature, 'invisible' to the eye.

Virtual spaces are constructed and mediated and offer new ways of interacting with others (Merchant, 2013). Drawing on two broad types of interaction, one can distinguish synchronous learning (with the use of interactive tools, such as instant messages, chatrooms, collaborative documents), and asynchronous learning (online projects, discussion forums, blogs etc.).

To support teaching and learning in virtual space it is important to plan the technological infrastructure together with the physical space: e.g. to think of accessibility of mobile technologies with sufficient Wi-Fi signal strength and number of power outlets; allow flexibility so that teachers and students could use the educational technologies freely.

Technology can support the development of new learning materials by allowing students to create multimedia, express their ideas, new concepts, and learning in new ways as well as participate in highly interactive environments. Such materials should be designed carefully and embedded in instructional approaches. Well implemented technology and a virtual classroom space should provide more opportunity for collaboration, space for discussions and presentations, a pool of resources to search through and share information, on top of connectivity and access to global and local networks. It eases differentiation and almost guarantees a personalized approach to building knowledge. This can be a challenge for educators because it is yet another environment they need to influence. The issue of setting up technological or 'digital spaces' is considered in more depth in Chapter 3.

Conclusion

The spaces our students inhabit are important assets in learning and teaching and should be catered to the needs of all its participants, not be a limiting factor on teaching choices. It should be designed and modified carefully taking into account the shift towards student-centred learning and remain flexible enough to facilitate a wide range of teaching practices. Importantly, it must be carefully planned according to the needs of learners and the specific pedagogical approaches.

In the present Chapter, key elements and principles in space design of classrooms were drawn from the literature review. These can be used for new architectural solutions, as well as to modernize the existing classroom infrastructures.

The key principle in space design becomes user-orientation – the necessity to address the actual needs of the potential users, both students and teachers.

In particular, the Future Classroom Lab with its six zones, each representing a pedagogical concept, is seen as a helpful and inspiring way to explore how the space can support different approaches and aspects of teaching and learning. Basic guidelines for multiple-use spaces recognize that different types of activities have different implications for spaces. Innovative learning spaces should pay attention to these differences, making variegated use more effective.

The literature review also considered space design as an important element affecting a learner's emotional, cognitive and behavioural engagements. The literature also revealed certain spatial conditions which affect productivity, concentration and engagement, and significantly influence the sense of well-being and comfort. It named several key factors to create aesthetically and ergonomically pleasing classroom environments that may support positive teaching and learning experiences. Finally, the virtual space is seen as an important

extension of the classroom that offers new opportunities for learning. Therefore, the technological aspect should also be considered in design of innovative learning spaces.

However, learning environments per se do not contribute to changes. The primary force of change comes from the educator's understanding of spatial conditions within the learning space and the need to connect space design in order to positively influence the teaching and learning practice. The next chapter focuses on the second, very significant, dimension of the framework – pedagogy.

Chapter 2: Pedagogy

Theoretical Background

The central argument of the present methodological framework is that effective pedagogy and strategically designed spaces along with technology are the three essential components of a 21st century learning environment. The present chapter considers the key element in the framework which is *innovative pedagogy*. Without any change in pedagogy, new or redesigned technology-enhanced classrooms will have no impact on learning. Thus, the present chapter presents literature review around the following key strands: (1) innovative pedagogy and examples of innovative pedagogical approaches which help develop so-called twenty-first century skills; (2) technology-enhanced pedagogy and pedagogical approaches.

Innovative Pedagogy: Concept clarification

Education is being increasingly called upon to respond to global, technological and economic transformations in order to prepare students for their future. A shift towards a more collaborative, student-centred approach, the transformative power of globalisation, the knowledge-economy developments and technological innovations of the 21st century, the advancement of a digital world, and direct and indirect policy guidelines and reports have significantly influenced pedagogical models. Moreover, mixed findings on the impact of technology use on learner outcomes flag the need to rethink the way teachers are using technology to support learning (Fullan & Langworthy, 2014; Caena & Redecker, 2019). Furthermore, learning is deeply rooted in specific social and cultural contexts. Therefore, such social and cultural phenomena as technology and new models of space organisation influence what defines effective pedagogy.

Pedagogy is the study of the educational process. It involves ways of knowing, as well as ways of doing. Pedagogy as a science explores the processes by which society can deliberately transmit its accumulated knowledge, skills and values from one generation to another. More than that, the aim of education is to create autonomous learners by facilitating their thinking and problem-solving skills which can be used in a range of different situations (Bruner, 1961). Like other applied disciplines, it is concerned with how we understand the practice, and how we apply theoretical understating in practice (Beetham & Sharpe, 2007). The main pedagogical questions are: How to educate students? How to improve students' learning? And how to meet their diverse needs?

In the present work, innovative pedagogy is defined as a teaching practice or approach that is often new to a given context, and which can lead to improved students' outcomes, i.e. students' positive cognitive and social development (European Commission, 2018). Innovative pedagogy as a science and practice has a responsibility to prepare citizens of the knowledge society who can be critical thinkers, be lifelong learners, be creative, cope with change, manage and analyze information, work with knowledge, and utilize Information and Communication Technologies (ICT). Indeed, innovative pedagogies can play a role in fostering and developing systematically what is often called in policy strategies "21st-century skills and competencies" (Ananiadou & Claro, 2009; Binkley et al., 2012).

At European Union policy level, the reports by the European Commission (2018) and UNESCO (2013) declared 21st-century key competencies and skills, which required a shift towards more active and engaging types of pedagogy, be put to the forefront.

The key competences for lifelong learning determined by the European Commission (2018) can be listed as: communication, mathematical competence and basic competences in science and technology, digital competence, learning to learn, social and civic competences, collaborating with other people, cultural awareness and expression, entrepreneurship. UNESCO (2013) defined the following transversal skills: critical and innovative thinking, interpersonal skills, intrapersonal skills, global citizenship, media and information. The next section looks at possible pedagogical approaches that are claimed to support the development of these competences.

Active Learning as Learning-Centred Teaching and Student-Centred Approach

The current circumstances today, where knowledge is rapidly expanding and technologies are rapidly changing, requires certain abilities. As discussed above, they include critical thinking and problem-solving skills; the capacity to find, analyze, and apply knowledge in new situations; interpersonal skills that allow to work with others and engage in cross-cultural contexts; self-directional abilities that allow managing their work; abilities to find reliable resources; and the capacity to communicate effectively. This requires a kind of teaching and learning that supports higher-order thinking and skills. It has been argued in the literature that these can be best developed through inquiry and investigation as a major learning strategy, application of knowledge to new situations and problems, construction of ideas, and collaborative problem-solving (Barron & Darling-Hammond, 2008; Pellegrino, 2020).

A few pedagogical approaches have emerged that place learners at the centre and are designed to promote and enhance meaningful learning. While not new, active learning pedagogies are gaining momentum in the academic literature and establishing policy

guidelines as a solution for enhanced students' motivation, achievement and 21st-century skills development have become the baseline for standards.

Active learning pedagogies belong to the constructivist epistemology and are characterised by learner-centeredness; a focus on knowledge creation, on process and content; interdisciplinarity; collaboration; a focus on student reflection; and the importance in intrinsically motivating student work (Bruner, 1961; Cattaneo, 2017; Freire, 1993; Jonassen, 1999). Active learning is a process in which students participate in the construction of facts, ideas and skills through the performance of tasks and activities actively led by the instructor (Bell & Kahrhoff, 2006).

Active learning is a process whereby students engage in activities such as reading, writing, discussion, collaboration, researching, practicing, producing or problem-solving that promote analysis, synthesis, and evaluation of class content (University of New Hampshire, 2020). Learning occurs when students make connections to their existing concepts, knowledge, and experience (Cherney, 2015).

Active learning is derived from the assumption that learning is an active effort. During active learning, students participate in their learning actively by discovering, processing, and applying information. Students engage in higher-order thinking tasks such as analysis, synthesis, and evaluation (ibid).

Next, we consider typologies of active learning pedagogy. We give an overview of key elements and teacher strategies; and describe pedagogical approaches that are strongly focused on learner engagement and collaboration, foster critical thinking and are grounded in what is relevant to learners.

Typologies of Active Learning Pedagogy

Active Learning Elements

The core elements of active learning are student activity and engagement in the learning process. This can be achieved through a variety of approaches and strategies to engage students in reading, speaking and listening, writing, collaborating, discussing, investigating and creating. Importantly, active learning requires students to do meaningful learning activities and think about what they are doing as individuals, pairs or groups. Key is to consider the needs of the learner and to increase the role of the student in the learning process. Below are listed key elements of active learning to meet that end.

- *Differentiation:* instruction, activities, teaching strategies should be informed by detailed knowledge about students 'specific strengths, needs and areas for growth.
- *Collaboration:* any instructional method in which students work together towards a common goal. The emphasis is on student interactions rather than learning as solitary activity.
- *Inquiry:* an instructional method that starts with a relevant problem that aims to motivate students. It is always active and usually collaborative, and involves significant amounts of self-directed learning on the part of the students.
- *Reflection:* It is critical that students construct and evolve their knowledge structures actively by taking responsibility and initiative for their learning. Von Wright (1992) describes reflection as the ability to think about the consequences and implications of actions and the ability to think about oneself as an intentional subject of one's own actions. Students require feedback and reflection to manage their own learning and improve their skills such as intentional learning, metacognitive learning and life-long learning. Thus, students monitor and modify their learning activities in a better way.
- *Formative Assessment:* using formal or informal procedures to gather evidence of learning during the learning process, and used to adapt teaching to meet student needs. The process allows teachers and students to collect information about student progress, and to suggest adjustments to the teacher's approach to instruction and the student's approach to learning.

Arguably, these elements can be complimented with the key concepts described in the FCL Project (see Chapter 1): to create, interact, present, investigate, exchange and develop.

Active Learning Strategies

According to Bell and Kahrhoff (2006), choosing the right active learning strategy is vital for student learning. The typical method for selecting an appropriate active learning strategy has been based on teaching experience or adaptation of what has worked for others. The active learning strategies are numerous and their key objective is to involve students in doing things and thinking about what they are doing. Importantly, the approaches need to activate students' higher-order thinking and metacognition (thinking about learning), and tend to emphasise students 'explorations of their own attitudes and values (Brame, 2018).

To give an idea of what Active Learning strategies look like, below are examples that can be implemented in any classroom. They can complement or replace direct instruction, stimulate discussion, aim to place more responsibility and autonomy on learners or focus on working and learning with others.

- *The Pause Procedure:* The teacher asks the students to write down everything they can remember from the previous segment of the class.
- *Think-pair-share-square:* First, the teacher asks students a question that requires higher-order thinking skills. Students turn to the person next to them to discuss their ideas with a partner. Students share answers with another group. Two pairs work together as a new group to complete the task of agreeing on a response from the first two answers that the pairs have come up with. They also elect who will be speaking. This stage is crucial for extracting the high-level explanation behind why an answer was chosen. This reduces the number of answers that a teacher has to elicit from a class. It helps promote student learning as students discuss and teach each other.
- *Jigsaw Group Projects:* In jigsaw projects, each member of a group is asked to complete some discrete part of an assignment. Every member who has the same discrete part of the assignment comes together to study. When these members have completed their assigned task, the pieces of each group are joined together to form a finished project.
- *Strip Sequence:* Teacher gives students the steps of a process on mixed strips of paper and asks them to work together to reconstruct the proper sequence. This approach can strengthen students' logical thinking processes and test their mental model of a process.
- *Concept maps:* Concept maps are visual representations of the relationships between concepts. The concepts are placed in nodes (often circles), and the relationships between them are indicated by labelled arrows connecting the concepts. The teacher tells students to create a concept map, identify key concepts to map in small groups or as a whole class. The teacher asks students to determine the general relationships between the concepts and to organize them two by two by drawing arrows between the related concepts and labelling them with a short phrase to describe the relationship.
- *Case-based learning:* The teacher provides a case to students by asking them to decide what they know is relevant to the case, what other information they may need, and what impact their decisions may have; considering the broader implications of their decisions. The teacher gives the small groups (3-5) of students some time to consider the answers, circulate to ask questions, and provide help as needed. The teacher provides opportunities for groups to share responses. The greatest value of case-based learning comes from the complexity and variety of responses that can be generated.

There are other active learning strategies and approaches. Next, we present examples of more structured and technology-enhanced approaches to active learning.

Technology-Enhanced Pedagogical Approaches to Active Learning

As discussed in Chapter 1, teaching and learning in the 21st century goes beyond the conventional physical space and time of the classroom. ICT can enhance and strengthen active learning pedagogy, and encourage students' participation in active learning activities. Open-source software, web apps, and almost ever-present mobile technologies engage students in constructing, building or creating products that represent and reinforce their learning. Technology can also support knowledge construction. Thus, ICT used in active learning can facilitate higher-order thinking skills of the students.

Innovative pedagogical approaches can harness the power of technology to encourage discussion and collaboration, give students an active role, promote complex cognitive processes such as analysis and solving complex, authentic tasks, that is use popular technologies for pedagogical purposes.

Technology-enhanced pedagogy

The idea of technology-enhanced teaching and learning is pervasive in literature related to digital technology in education. But in most cases authors rely on not sufficiently scrutinized models or frameworks, constructing on those models their claims and implementations and thus lacking a critical stance on the robustness of the underlying rationale.

Bower and Vlachopoulos (2018) reviewed and analysed 21 design models for technology-enhanced learning in the classroom and concluded that those models were more often conceptual than procedural, and sometimes both. The background for those models either relies on a social-constructivist pedagogical and epistemological basis, or adopt a variety of pedagogies that can be opted in the model, or do not discuss at all the pedagogical basis of the model. As a consequence, the reviewed models rarely provide consideration of the interactions between students and teachers, and quite often remain on the theoretical formulation of general principles. The lack of evaluation of the implementation of the models plays against its credibility.

Bower and Vlachopoulos (2018) recommend that technology-enhanced learning models should (i) clarify whether a framework is a procedural or conceptual, and if it has elements of both, ensure that the concepts and processes are sufficiently integrated, (ii) clearly specify its pedagogical orientation, (iii) consider contextual issues for learning design, (iv) provide an illustration of the application of principles and guidelines, (v) consider the dimension of interaction students-teachers, (vi) include technology guidance for the teacher, and (vii) provide orientation for the assessment of its efficacy when applied in real classrooms.

And the authors conclude that we should take care not to place too much stead in technology-enhanced learning design frameworks because there will always be several aspects of the design process that they cannot capture.

"Perhaps the Holy Grail of technology-enhanced learning design models would be a demonstration that (…) the use of a particular model resulted in learning designs that produce significantly better learning outcomes for students who used those designs. However, we should not hold our breath for such a model to manifest, because of the intrinsic complexity and artistry involved in design" (Bower & Vlachopoulos, 2018, p.992).

Hence, the potential of technology is dependent on the pedagogical practice and the success or failure of technology-enhanced learning is dependent on how teachers frame activity in which students are engaged.

UNESCO's Institute for Information Technology has examined pedagogical strategies of the teachers by applying Morel's Matrix that evaluates the degree of pedagogy in four distinct phases: (a) emerging, (b) applying, (c) integrating, and (d) transforming (UNESCO, 2003). In the emerging phase, teachers meet ICT tools, but their classrooms are teacher-centred. In applying phase, teachers try to use ICT tools as a separate subject, and their classrooms are still teacher-centred. In the integrating phase, teachers integrate ICT tools into their teaching process, their classrooms are learner-centred, and they support collaborative learning. In transforming phase, teachers support critical thinking, preferred learning styles, experimental and collaborative learning in their classrooms.

Next, a focus is placed on technology-enhanced pedagogical approaches that support Active Learning, and contribute to the creation of a student-centred environment, and would be placed in integrating and transforming phases. They are structured in a form of a table to ease the grasp of those.

Blended Learning "The organic integration of thoughtfully selected and complementary face-to-face and online approaches" (Garrison & Vaughan 2008, p. 148)	
Benefits • to maximise the benefits of technology and digital resources; • to improve the differentiation of instruction and to foster classroom interaction (Paniagua & Istance, 2018); • to create flexible modes of education, and personalized learning environments.	**Challenges and Action** • A key principle is to support systematic inquiry, communication and reflection. Here, technology is an enabler and provides the means to stay connected and achieve collaboration. • Matching the organisation of content, the delivery of instruction and the assessment of learning outcomes with face-to-face and online communication characteristics represent a complex challenge.
Flipped Learning Aims to free up classroom time for students' questions, in-depth discussion, and personal feedback while students are asked to prepare for learning activities online (Watson, 2008)	
Benefits • allows for a variety of learning modes (can e.g.be combined with inquiry-based and collaborative approaches to promote more active and meaningful participation); • develops responsibility for learning.	**Challenges and Action** • the approach requires more scaffolding and feedback to help less independent students with concept acquisition; • face-to-face interactions are central since they offer more demanding and complex problem-solving tasks and enhance peer interactions; • learning activities should be designed directly about skills and knowledge the learners need to develop and acquire; • the role of the teacher is even more important and demanding.

Game-Based Learning Game-Based Learning includes four sets of pedagogies at its core: storytelling, assessment for learning/feedback, problem-solving, and experiential learning. (Paniagua & Istance (2018)).	
Benefits • can be applied in a wide range of subjects. • can enhance learner creativity, problem-solving, develop self-regulated learning; • promotes engagement and sustains motivation in learning. • connects the academic part of school culture to their own youth culture; • offers educational benefits for students such as engagement, the harnessing of student emotion, encouragement of customised thinking.	**Challenges and Action** • The need to engage in game-based learning that can teach complex rules, introduce the students to unfamiliar worlds, and engage them in tasks and logics without prior skills, by creating a feeling of 'flow'. • The main challenge is how to make game mechanisms support learning rather than using games as rewards for learning.

Digital storytelling	Continuous Assessment	Problem-solving and experiential approaches
• focus on interpretation and critical thinking.; • To engage in dialogue with students about community issues, and have the potential to impact self and others (Lowenthal, 2009); • to engage multicultural classrooms in conversations around difference (Stewart & Gachago, 2016).	Good learning games embed seamless assessment and just-in-time feedback directly into the game (Shute & Ke, 2012) by blurring the lines between learning content and assessment.	• The learners are required to make decisions and solve increasingly difficult problems. • The goal is to incorporate learners' experience and real-life topics into the narratives and challenges of the game-like tasks (Paniagua & Istance, 2018).

Project-Based Learning	
Aims to engage students in learning through the application of content knowledge and skills in real-life or hypothetic situations. Teaching guidance is reduced to give students an active role and voice, which includes the selection of the project and the way it is developed.	
Benefits	**Challenges and Action**
Students practice and learn how to interact with others, work in diverse teams, and participate in different roles as participants, mentors, or leaders (Binkley et al., 2012).	Authentic learning projects are interdisciplinary by nature. This implies that physical arrangement of the learning spaces in a school should support communication among subject areas as well as access to materials, technology, and experts in different domains.
Maker-centred project-based learning	
Learning is hands-on, student-driven, and product-oriented where goals are negotiated over the course of a project.	
Benefits	**Challenges and Action**
• In making activities, students learn while they make activities by working with tools and materials, tinker with developing a playful, problem-solving mindset, or engineer something shareable and publicly accessible to presentations (Martinez & Stager, 2013). • Effective in inclusive classes: the projects are adaptable to different kinds of learners and provide a structure in which the teacher can differentiate the process of creation (Martinez & Stager, 2013).	• Makerspaces are needed where students create or make various products by using the tools and materials to represent their knowledge and interests. • Requires clear instructions regarding the tasks and visible learning goals to support students, so that they could lead to productive interaction in the group. This is important to sustain active participation. Teacher-directed reflective discussions as significant aspects of project-based learning are central to improve students' cooperative skills and promote inclusion-related participation (Sormunen et al., 2020).

Computational Thinking (CT)	
Computational Thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent (Wing, 2006; 2011). The CT practices include design and development of computational artifacts, models, simulations; artifacts of natural and artificial phenomena collaboratively and the implementation of computing techniques to solve problems, such as coding, programming and robotics	
Benefits	**Challenges and Action**
• to develop creativity, critical thinking and problem solving through the key elements: logical reasoning, decomposition (breaking down one complex problem into many smaller ones); algorithms (creation of step-by-step instructions, description of routines); abstraction (capturing the essential structure of a problem); and identification of patterns (Paniagua & Istance, 2018); • to engage young children in active and playful learning activities through building and programming tangible robotic devices.	• Apart from access to technological resources, teachers require professional development sessions to develop an understanding of CT concepts and strategies to bring this understanding into practice. • Resources such as time for professional development, access to computing tools in the classrooms, and engaging with CT leaders to discuss approaches to CT in the classroom. • The need to articulate the connection between CT and all academic disciplines, to develop content to support integration into curricula, and to take the lead in designing and facilitating both preservice and in-service opportunities for learning (Yadav et al. (2016)).

Active Learning approaches described above have a number of common characteristics. They are of collaborative and in some cases interdisciplinary nature; promote students' engagement; involve communication, peer-work, research, learning by doing and reflective practice, and constant feedback; and seek to develop digital skills. The learning experiences should be inclusive and relevant to students. They aim to foster creativity, independent learning, critical thinking, problem-solving and decision making. In essence, the active learning pedagogies can be mixed to attend to the needs and to more fully leverage learner agency and motivational capacity.

Conclusion

The present Chapter aimed to clarify the key concept for the framework - what is meant by innovative pedagogy and active learning. It was highlighted that active learning pedagogy is characterised by learner-centeredness; a focus on knowledge creation, on process and

content; interdisciplinarity; collaboration; a focus on student reflection; and the importance in intrinsically motivating student work. The chapter discussed how this can be supported through strategies and approaches. It was shown that space design and technology can play an important role in enhancing active learning supporting teaching goals, content, and learning process.

Pedagogy is at the heart of change in educational spaces and space design. Its task becomes to create certain learning environments that engage students actively in learning, encourage social interaction, enable collaboration, and reflexivity on learning, reflect various styles of learning and importantly are learner-centred.

Chapter 3: Technology

Theoretical background

Technology and education

According to OECD (2018), digital technologies constitute a drive of change leading to the improvement of students' learning outcomes. In fact, digital technology tends to be part of the key drivers that educational systems around the world recognize as relevant to improve learning. This is also the case of the major education systems' stakeholders, including parents' and teachers' associations. The rationale beyond that recognition is related to the very idea of innovation in education and indeed to the notion of technology-based school innovation (OECD, 2010). Three main claims are present in this discussion:

- digital technologies offer opportunities to the customisation of learning and adaptation to learners' individual needs thus improving teaching and learning;
- consolidated digital technology literacy represents a social-economic asset that education should provide to all;
- higher-order competencies (often referred to as 21st Century Skills) are crucial for the development of the social world, today and in the future.

Besides the increasingly connected generation Z (Sparks & Honey, 2015) which populates schools in most countries – certainly highly dependent on digital technology in all their social and cultural practices – teacher education institutions and educational systems do not seem to acknowledge the phenomenon (Goktas, Yildirim & Yildirim, 2009). This seems to be a contradictory situation that many academics address in research. Students bring to school beliefs and perceptions to learning environments that clash with the schooling learning experiences and, in particular, the role that digital technologies should play there. This is also referred by PISA reports when they point that in most OECD countries more than 80% of 15 years-old use computers frequently yet a clear majority seldom use them in the school (OECD, 2010). But, at work, the generation Z will structure their professional lives much as they do their non-working lives, that is, across spaces and connections that help them develop (Sparks & Honey, 2015).

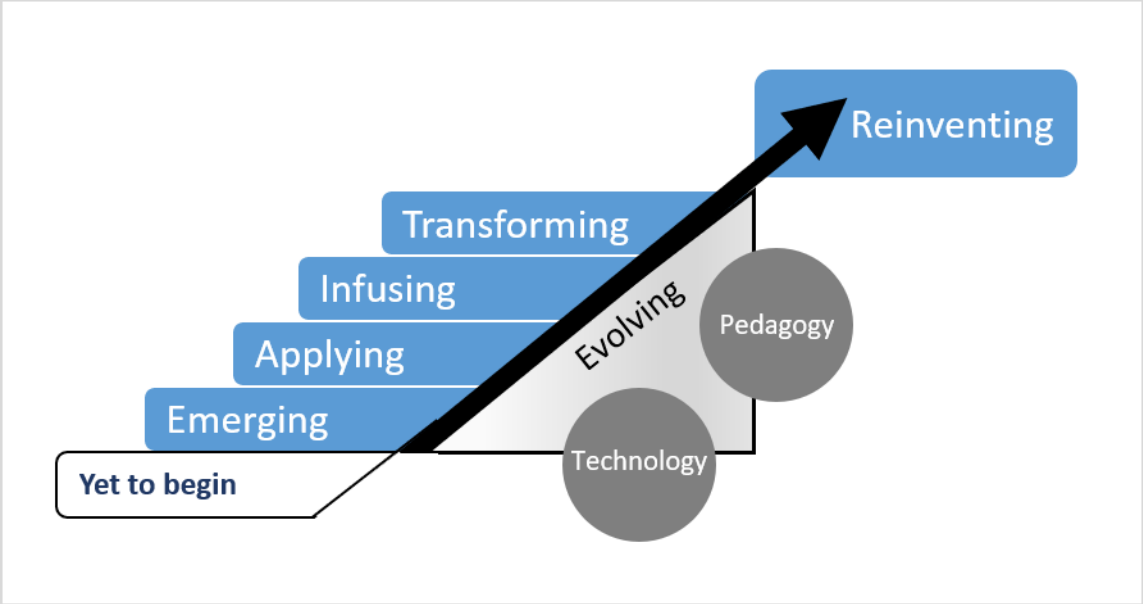

Figure 4: Stages of digital technologies integration in education (Groff, 2010)

As Groff (2010) puts it: "*Some of the web-based innovations that have become quite pervasive in the larger digital culture of our world fit seamlessly into current curricular structures and programs, and are often free and easily accessible. (…) Other technologies are more disruptive innovations, appearing on the periphery of the educational landscape and are just beginning to see their full potential. These second-order innovations are lowly gaining attention and traction in the field, and will likely see increased development and application over the next decade.*" (p.5)

The challenge faced by schools and teachers is to cope with a contradictory system where educational authorities seem to slow down innovative movements that call for a 'new school environment' the urge of students, at all school levels, to devaluate activities where digital technologies and wireless connection are not available.

Digital technologies and innovative learning spaces

Technologies are an integral part of schooling practices. Analogue technologies – such as books, maps and all kind of traditional manipulative objects – have always had their place in classrooms. However, digital technologies transformed the landscape of possibilities while bringing a new domain – the digital – in many cases merging and interfacing with the analogic artefacts.

In parallel, digital technologies linked to wireless internet services made access possible both to a vast field of web resources as well as to fast and synchronous communication. This

transformed the nature of the school learning space while providing a virtual dimension to the physical space and therefore expanding the possibilities for the kind and scope of activities that students can play in the school and creating a possible continuum between school space and home-space. This is crucial to understand the innovative nature of learning spaces.

Goodyear and Retalis (2010) clarify: "*Technology, in its broadest sense can include both hardware – interactive whiteboards, smart tables, handheld technologies, tangible objects – and software – computer-supported collaborative learning systems, learning management systems, simulation modelling tools, online repositories of learning content and scientific data, educational games, web 2.0 social applications, 3D virtual reality, etc.*" (p. 8)

Learning environments evolved with such technologies as visualized by Adu and Poo (2014) in Figure 5.

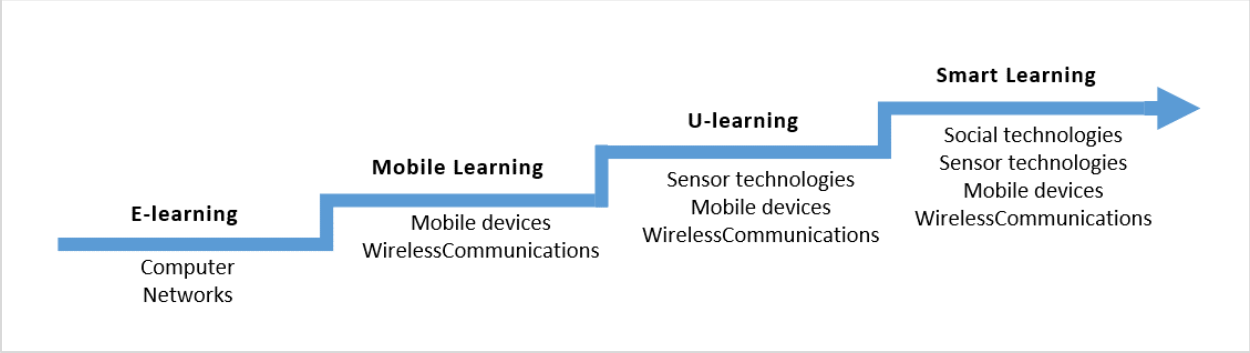

Figure 5: Evolution of technology-enhanced learning

Keeping the assumed relevance of digital technologies in the background within education, one can interpret the strategic role of innovative learning spaces in teaching and learning assuming that they: (i) provide flexibility in space organization that leads to flexibility and variety of activities thus suggesting flexibility in learning, (ii) encourage fruitful articulation of activities and space giving the ability to answer the needs identified and to easily reposition learners and teachers; (iii) reify a view on pedagogies that value pupils' responsibility; (iv) accommodate digital technologies as an integral part of the habitat that makes school a living organism; (iv) tend to blur the differentiation between the space of the 'classroom' – as a specific space for pupils' learning – and a sort of working and meeting place for teachers' professional development activities. As stated by Bannister (2017, p.14), a "learning lab is a space for practice but also for reflection" creating multiple dialogues that involve teachers, pupils and parents, school leaders, commercial partners and policymakers. Additionally, future learning spaces may be seen as an incubator of ideas emerging from co-flection of teachers, therefore contributing in relevant forms do their professional development.

Typologies and strategies of digital technology

Independently of the specific physical configuration of the learning space, digital technologies are in any case structuring resources of possible activities in the sense that they afford possibilities but shouldn't be understood as the starting point of pedagogical work.

Key strategies for the implementation of teacher education actions that prepare teachers to act with digital technologies in innovative forms within future learning spaces, implies that we assume some fundamental principles.

Principles – Digital Technologies (DT) in teacher practices

Principle	***Possible actions/aims***
DT should be able to put in dialogue the (possible) different learning space zones	to position the technology artefacts in ways that do not isolate specific physical areas of the learning space
DT should position students as core participants in the learning space	to stimulate students' engagement
	to develop students' understanding of their activity as learners
DT should serve the learning design assuming the social nature of learning	to stimulate co-creation of activities
	to actively encourage cooperative learning
DT use in teaching activities should attend to students' individual differences as learners	to be accurately sensitive to different learning styles, prior knowledge, affective responses
DT ask for hard and meaningful work and challenge from students without excessive overload	to avoid the centrality of digital technology putting the focus on strategic objectives
DT support assessment and feedback strategies that are consistent with students' expectations	to make available and apparent powerful ideas that students can take onboard about feedback and formative assessment
DT should promote horizontal connectedness across areas of knowledge and subjects	to get an interdisciplinary/transdisciplinary view on education

Principles - Digital Technology tools in innovative learning spaces

Principle	***DT typology***	***Examples of possible actions***
DT should be as movable as possible reinforcing the flexibility of the learning space	all sort of mobile technology	students and teachers make decisions about which technology to use and where to locate it in the learning space according to their aims and activities
DT should be able to act as a mediation tool for the whole group of students	large digital display	teacher or students' presentation, illustration, discussion, summary display of ideas under discussion, …
DT should allow students to act (one by one or in group) in public	wireless large digital display (multitouch)	students collaborate in common activities or produce part-task procedures
DT should provide opportunities to an exploration of problems and challenges in the web	wireless computing mobile technology (smartphones, tablets, laptops, , …)	students explore problems or topics searching for sources in guided or unguided exploration (information, datamining, public statistics, …)
DT should provide opportunities to exploration of problems and challenges with tangible programming devices	robots, drones, smartphones, tablets	students may program tangible devices or explore microworlds that embed complex ideas and concepts
DT should allow video data collection and encourage the production of (individual and collective) digital products	digital video cameras with editing functionalities	students videotape physical experiments in the learning space or phenomena out of school including interviews, photos, etc.
DT should allow and encourage modelling and physical outputs	3D printers 3D scanners	students plan and execute 3D pieces for specific purposes or serving task-part projects
DT available in the learning space should encourage prospective views on education	virtual reality headsets augmented reality software or mixed reality immersive software	students experiment the possibilities of virtual reality for exploration of phenomena and create instances of augmented reality for illustration in their projects

DT should allow data collection and analysis	movement, light, and touch sensors data analysis software	students collect real data and produce analysis
DT should encourage communication with others and provide opportunities to contact with peers and experts outside school	videoconferencing systems	students schedule and run videoconferencing with peers (in national or international level) about specific projects under way
DT should be ready-to-use 24/7 in the learning space	Mobile, laptop, charging station and locker	students use of technology is guaranteed by full charge every time they need to use it
DT should create possibilities of continuity between school and home activities	learning management systems	students share the development of their co-created learning scenarios and publish the outputs
DT should signal both the individualization of learning and the collective nature of knowledge	learning management systems	students both save their productions in an individual area as well share and /or co-create them with the class
DT support innovative forms of assessment	Web-based assessment software/ learning analytics tools	students practice peer-review feedback and assessment; teacher uses remote forms of assessment and feedback
DT policy in an innovative learning space should adopt a BYOD approach	power charging network available	when and where possible, a BYOD-Bring Your Own Device approach should be encouraged in teacher education programs

Both face-to-face and virtual dimensions should be considered when adopting technologies to be used by pupils and teachers in innovative learning spaces. Student teachers should have significant experience and be immersed as far as possible in technology rich-environments during their initial training. This includes both face-to-face activities as well as synchronous and asynchronous online sessions.

A number of apps are available that serve different learning purposes. However, the future teacher must understand the different typologies of technologies (both hardware and software) and its innovative and creative use in school activities, instead of just knowing about specific software. Examples of hardware and software used in initial teacher education should

be positioned within typologies of pedagogies and connected to its innovative use in teaching.

The Bring Your Own Device (BYOD) policy is a trend that teacher educators should understand although it requires - as in every use of technology by pupils - careful attention to issues related to safe technology use, as well as other technical requirements (equipment specifications and management, the knowledge required for dealing with diversified equipment in the classrooms, etc.).

Mobile touchable large screens are an added value as they allow sharing ideas that are immediately visible to others in the learning space for representation, collaboration, etc. that can be easily saved and shared in the class virtual space.

Setting-up an innovative future learning space should take into consideration the dynamic character of digital technology development, thus a continuous up-to-date process should be in the agenda of staff in charge of the technology dimension of the learning space. Additionally, the very concept of innovation cycle should be included in the implementation of a learning space with all its implications both for digital technology as well as for pedagogies and teachers 'professional development.

Challenges of Technology-Enhanced Learning Environments

It takes a long time to adopt new technology and redesign teaching practices. Singh and Hassan (2017) point out that teachers can keep employing teaching methods of the past despite change in learning environments.

A study related to challenges of the mobile learning environment in Sweden highlights that the most important drawback is the support staff for students and teachers (Asiimwe, Grönlund & Hatakka, 2017). Without adequate technology equipment and support, teachers' activities will be limited.

Training teachers focusing on how to enhance pedagogical skills, create content or teaching materials, share it online, and how to use various ICT tools cannot solely satisfy the end goal, an effective integration of technology in the learning space.

Infrastructure (e.g. lack of computers, adequate space, interactive board, unreliable Internet connections, etc.) can be a major problem when financial resources are not sufficient (Andersson, 2008; Fu, 2013).

It is important to make policy guidelines for usage and practices of ICT. Policies related to "ICT plan, ICT support and ICT training have a significant effect on class use of ICT" (Tondeur et al., 2008, p. 212) to increase the quality of education.

Conclusion

The present Chapter examined the role of technology in teaching and learning, considered the nature of the digital space and presented key principles for the use of digital technologies in educational spaces and in teaching and learning practices.

The critical idea here is that transforming education through technology must transcend its use simply as a lever, and must be utilized appropriately to enrich the methods and approaches in their incorporation into a learning space. Emerging evidence suggests that the well implemented use of digital technologies can transform whole learning environments, education systems and schools themselves, however the complete scope of its impact is hard to determine because it is a fast evolving process that requires on going analysis. It certainly should be spotlighted in initial teacher education programs, and perhaps is a sure-fire way to reinvent the traditional and fundamental model that drives schools' organisation of learning and teaching today.

Chapter 4: Conclusion and Recommendations

The intention of the present document was to present a comprehensive literature review on designing innovative learning spaces – bringing together three key pillars: Space Design, Pedagogy and Technology. It aimed to clarify the key concepts and discuss foundational principles and strategies in designing technology-enhanced learning spaces, and finding appropriate pedagogical approaches.

The physical space our students and teachers inhabit can become a third teacher when it enriches teaching and learning. It remains an important mediator of learning. There is, however, a complex relationship between space design and its use, or learning spaces and pedagogy. Drawing on the FCL Project model, thinking of space in verbs (something that we do) is helpful to understand the interrelation of space and pedagogy. In space design, the starting point is the theory of learning, a vision for educational goals, the learners' needs and possible teaching and learning activities that follow.

Interestingly, with the emerging trend of FILS, space is not assumed as given any more. There is a growing expectation that teachers will lead learning space endeavors within their schools. This means that knowledge of design, layout, and technologies of a space - and understanding and skill to integrate it in teaching and learning practices, in particular for formative assessment, personalisation, collaboration and creativity - should be included into teacher professional competence and knowledge frameworks. In fact, teacher education has been characterised as transformative in a way that it can shape the necessary dispositions, and develop the needed competency to engage students in meaningful learning – applying pedagogy, space and technology.

Thus, we conclude with the following strategies and recommendations for implementing innovative pedagogy in schools and the integration of technology-enhanced space into teaching and learning. These are considered at four levels: system and policy level, teacher education, school level, and classroom level.

System and Policy Level

- Innovation in pedagogy must respond to the needs of students and teachers, integrate into local contexts and environments, and is a continuous learning process that follows a long-term vision.

- There is a complex relationship between technology, content, pedagogy, and changing contextual realities. Therefore, the integration of technology and space in education must be holistic.
- There is a need for teaching spaces that enable a learner-centric culture and engage teachers creatively with their development to meet the changing demands of societies and the educational curricula. Space is a fundamental element in the teaching-learning process and must therefore be carefully planned according to the needs of learners and the specific methodological options.
- Teachers need to be prepared and provided with necessary professional competence, tools and resources to change their practice. In this, both initial teacher education and professional development play an important role.
- Fostering teacher exchange is a powerful strategy to make professional development sustainable. However, it is crucial to validate the creation and exchange process through official support and recognition from school authorities and the system to encourage teachers to participate.
- There is a value in collaborative practices between teacher education institutions, space designers, and school leaders and teachers to achieve effective integration of space design into the classroom.
- It is important to develop a national framework to embed a shared understanding of teachers' professional spatial and digital competence across teacher education institutions.
- There is a need to support joint training of teacher educators and teachers in national/local Innovative Learning Spaces (e.g. Future Classroom Labs).

Teacher Education

- A comprehensive introduction to the value and power of open practice should be part of the initial teacher education experience as well as their continuous professional development so that student teachers have every opportunity to develop strong personal decision-making and meaning. For this, a creation of innovative learning spaces (e.g. Future Classroom Lab) within the ITE institutions is important. This gives opportunities to practise and experiment.
- Teacher education programmes should emphasize technology training in authentic teaching situations.
- ICT should not be delivered as stand-alone modules, but be infused into the whole Initial Teacher Education programme so that the teachers can integrate ICT into their classroom practices, and avoid isolating pedagogy from technology. This is relevant to the development of spatial competence.

- Scenario-based learning approach can be effectively applied in teacher training to provide experiential, iterative, action-oriented learning. The approach aims to stimulate creative and critical thinking, reflectivity, enhance teachers' ability to adapt to change, and capability to implement new practices and methods.
- Teacher educators should model the use of technology; the importance of reflection on the role of technology in education; instructional design; collaborating with his colleagues; scaffolding authentic technological experiences; and continuous feedback.

School Level

- Space is a fundamental element in the teaching-learning process and, therefore, must be carefully planned according to the needs of the students and the active learning methodologies.
- There is a need for synergy between architects and educators through interdisciplinary conversations to build active learning spaces in schools.
- The participatory design of innovative learning spaces is important to raise awareness of the relationship between the physical environment and pedagogical practices to develop a shared pedagogical vision and achieve meaningful use of innovative spaces. There is a need to strengthen the knowledge and skills of teachers through the design of learning spaces since it should allow for active and creative management of educational spaces.
- The mandatory schedule of the use of innovative learning spaces in schools can be useful to increase the effectiveness of these spaces.

Classroom Level

- Innovative pedagogies can be combined to take full advantage of learning motivation.
- An important step is to raise awareness of the range of possible types of active learning activities within a particular content area, linking them to multiple ways that digital and non-digital technologies, and space can be used to support each type of learning activity.
- The classroom environment should foster interaction, collaboration and communication between students, but also give them the opportunity to have some time alone to research, read and collect information, and reflect on their learning experiences.
- Teachers should support critical thinking, preferred learning styles of students, collaborative and experimental learning in their classrooms and learning spaces.
- Teachers should include a spatial aspect in their teaching, they need to develop the ability to assess the spatial impact on learning and develop an understanding of

various spatial possibilities and how they can adapt pedagogies to accommodate emerging learning in such spaces.

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