

Chapter Outline:

- Definition of learning space
- PST framework
- Principles for learning space design
- Smart learning environment.

By the End of This Chapter, You Should Be Able To

- Recognize differences in informal and formal learning
- Define a learning space
- Understanding Pedagogy-Space-Technology design and evaluation framework
- Recall the principles of learning space design
- Clarify the element and technique features of smart learning environment
- Elaborate on two examples of learning space design.

Main Learning Activities

1. Take a few minutes to describe a particular learning space with which you are familiar. What pedagogical approach is used in that space? What technologies are involved? Is the space suitable for that pedagogical approach and those technologies? Explain why or why not.
2. Create a concept map that depicts the key features of a learning space. Describe a specific learning space for a formal learning situation and also one for an informal learning space. State what is needed to make each example a smart learning space.

9.1 Introduction

Learning is changing in the twenty-first century. Learning happens in classrooms, homes, communities, and indoor and outdoor settings. The design of a learning space is important for desirable learning outcomes. Furthermore, technology has evolved and transformed our lives and society and learning space is enhanced by current high-quality technologies, such as interactive tutorials, wireless networks, whiteboards, and mobile devices. Maximizing student's learning is a top priority in designing or redesigning a learning space. Well-designed learning spaces support pedagogical practices that engage, challenge, and equip students with the knowledge, skills, and attributes they need to succeed in a complex and rapidly changing world.

This chapter will present the definition of a learning space and discuss how to evaluate learning spaces. In addition, the discussion will focus on how technology has enabled the implementation of learning spaces, in particular the usage of smart technologies.

9.2 Learning Spaces

Previous learning spaces mainly occurred outdoors, such as in a forest. For example, the later Xiang Order (circa 1046—256 BCE), which included private schools, academies and outdoor venues as well as the Imperial College in China. The modern learning environment appeared after the *class teaching system* presented by Comenius in the sixteenth century in what is now called the Czech Republic (see <http://www.newworldencyclopedia.org/entry/Comenius>).

Since the 1990s, many new information technologies (e.g., multimedia, computers, digital projector, the Internet, courseware, network-based courses, tutorial Web sites and more) have entered into schools and classrooms. Learning spaces now constitute an emerging research area. The goal of a learning space is to promote independent, flexible, and engaged learning by providing learners with appropriate technologies and pedagogies. How to design and develop an effective learning space has thus become increasingly critical (Ellis & Goodyear, 2016).

9.2.1 Definition of Learning Space

Learning space refers to a place and the surroundings associated with that place where teaching and learning occur; it may refer to an indoor or outdoor location, or to a physical or virtual environment (for example, *the Journal of Learning Spaces* located at <http://libjournal.uncg.edu/index.php/jls>).

Formal learning is typically organized and structured and has learning objectives (OECD, 2017); formal learning is normally delivered by trained teachers in a systematic and intentional ways within a school or university.

Informal learning is any learning that has no set objective in terms of learning outcomes and is never intentional from learner's standpoint, such as self-directed learning or learning from experience, (OECD, 2017) which usually occurs in learning commons, multimedia sandbox, and residential study areas.

For both formal and informal learning, virtual learning environment refers to the kind of platform that supports mediated exchange of information between users and the system through such digital media as learning management systems, social media Web sites, and online virtual classrooms and environments.

Learning spaces are designed to support, facilitate, stimulate, or enhance learning, and teaching. A learning space can be designed to support listening and taking notes (e.g., a lecture hall or traditional classroom). New technologies have added to the complexity of designing effective learning spaces and now require careful consideration of the pedagogy to supported learning. The characteristics of a learning space and its components include many variables, such as size, forms, shapes, environmental setting, technologies involved, intended activities and users, and so on.

9.2.2 The Pedagogy-Space-Technology (PST) Framework

Creating a learning space that could be used to encourage students to become actively engaged, independent, lifelong learners is a chief aim of twentieth-century pedagogy and a challenge for the design of learning spaces. The point here is that there are connections between pedagogy, technology, and the design of a learning space. These connections are evident in the TPACK (technological pedagogical content knowledge) framework (Koehler & Mishra, 2007). There are a number of relationships among these connections which are elaborated later in line with the Pedagogy-Space-Technology (PST) framework (Fisher, 2005).

The sequencing of items in the PST framework (Fig. 9.1) is important. Each of the three elements (pedagogy, space, and technology) influences each other in a reciprocal manner. For example, a desired pedagogy suggests a preferred way to arrange and use the space. In addition, a particular technology to be deployed may better fit some pedagogies and arrangements of the space than other possibilities. A particular space places constraints (or presents opportunities) on the introduction of certain types of technology while a given technology can impact how a space is used by teachers and students. In addition, the content to be learned and the students themselves need to be taken into account.

Given the complexity and challenges of designing effective learning spaces that take into account the content, the learners, along with the pedagogy and technology involved, an iterative planning cycle that supports refinement and evaluation is often appropriate. Iterating through the PST framework several times during planning, development and the subsequent life cycle of a learning space is likely to

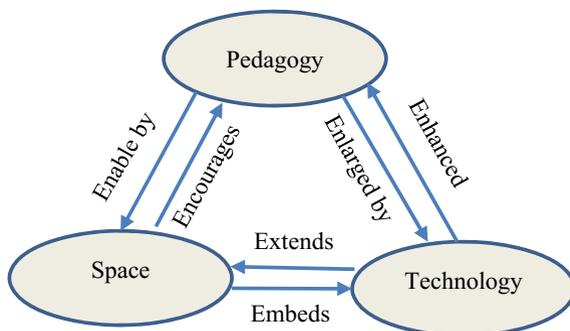


Fig. 9.1 Pedagogy-Space-Technology (PST) framework. Adapted from Fisher (2005)

have desirable outcomes; that is to say, think of PST as a cradle-to-grave framework. While only two life-cycle stages are represented in Table 9.1 (as the columns—Conception and Design and Implementation and Operation), the framework could be made more fine grained by splitting these into more than two columns corresponding to more life-cycle stages and writing appropriate questions for each stage. In addition, later stages could be added. Thus if a particular institution has a prescribed set of project stages with decision points (a.k.a., key milestones), then the basic PST framework questions can be rewritten to suit the declared delivery steps or key decision stages for the institution; PST can be tailored to meet particular ways of doing work.

9.3 Principles for Learning Space Design

In this section, a number of principles to guide the effective design of learning spaces are discussed. The first consideration, however, is to focus on the use of the learning space, namely the activities to be supported in the space.

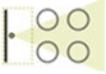
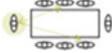
9.3.1 Linking Activities to a Learning Space

Multimodal learning settings can be collocated and clustered to allow in a space to fit the learning activities targeting those technologies. Some technologies and activities are useful in a wide variety of activities that make such clustering difficult. See Table 9.2 for a partial elaboration.

Table 9.1 Pedagogy-Space-Technology (PST) design and evaluation framework (adapted from Fisher, 2005)

Life-cycle stage		
Focus	Conception	Implementation and operation
Overall	<p>What is the motivation for the initiative? What is intended? What initiated the project? Who are the proponents and opponents? Who has to be persuaded about the idea? Why? What lessons were learned for the future?</p>	<p>What does success look like? Is the facility considered a success? By whom? Why? What is the evidence? Does this relate to the original motivation or intent? What lessons were learned for the future?</p>
Pedagogy	<p>What type(s) of learning and teaching are we trying to foster? Why? Why is this likely to make a difference to learning? What is the theory and evidence? What plans will be made to modify programs or courses to take advantage of the new facilities? What education or training for academics and other staff is built into the plan?</p>	<p>What type(s) of learning and teaching are observed to take place? What is the evidence? What evaluation methodology or approach was used and what methods were used to gather and analyze data? Who was included in the data gathering and analysis? Students? Faculty? Staff? Administrator? Senior Leadership? Facilities managers and technology staff?</p>
Space (including environs; furniture and fittings)	<p>What aspects of the design of the space and provisioning of furniture and fittings will foster these modes of learning (and teaching)? How? Who is involved in developing the design brief? Why? Which existing facilities will be considered in developing concepts? Can we prototype ideas? Who is involved in the assessment of concepts and detailed design? Why? What are their primary issues and concerns?</p>	<p>Which aspects of the space design and equipment worked and which did not? Why? What were the unexpected (unintended) uses of the space and facilities that aided learning or facilitated teaching? Do these present ideas for future projects? How was the effectiveness of the use of space to aid learning and teaching measured? What were the different metrics used? Where there synergies between this and other spaces that enhanced learning?</p>
Technology (ICT; lab and specialist equipment)	<p>What technology will be deployed to complement the space design in fostering the desired learning and teaching patterns? How? In establishing the brief and developing concepts and detailed designs, what is the relationship between the design of the space and the selection and integration of technology? What pedagogical improvements are suggested by the technology?</p>	<p>What technologies were most effective at enhancing learning and teaching? Why? What were the unexpected (unintended) impacts (positive and negative) of the technology on learning and teaching? How did technology enhance the continuum of learning and teaching across the campus and beyond?</p>

Table 9.2 Linking pedagogical activities to spatial settings (adapted from Fisher, 2005)

Pedagogical activity	Pedagogical attribute	Process steps	Behavioral premise	Spatial icon
Delivering	Formal presentations Instructor controls presentation Focus on presentation Passive learning	Prepare and generate presentation Deliver to an audience Assess understanding	Bring information before the public Instructor lead Knowledge is in one source	
Applying	Controlled observation One-to-one Master and apprentice alternative control Informal Active learning	Knowledge transferred via demonstration Practice by recipient Understanding achieved	Learner-centered Apprentice model	
Creating	Multiple disciplines Leaderless Egalitarian Distributed attention Privacy Casual Active learning	Research Recognize need Divergent thinking Incubate Interpret into product/innovation	Innovation or knowledge moved from abstract to a product	
Communicating	Knowledge is dispersed Impromptu delivery Casual Active learning	Organize information Deliver Receive and interpret Confirm	Share information Provide quick exchange	
Decision making	Knowledge is dispersed Information is shared Leader set final direction Situation is protected Semiformal to Formal Passive/active learning	Review data Generate strategy Plan Implement one course of action	Make decision	

9.3.2 Principles to Guide Design

The following principles constitute a high-level strategic guide for the design of new schools, the redevelopment of schools, and the repurposing of buildings and learning spaces to maximize student performance.

- **Sustainable—the space should be designed to be sustainable**
 - Enable a space to be easily reallocated and reconfigured.
 - Consider cost-effective items, utilities, delivery, and support.
 - Think ahead of future development of technologies, pedagogies, and uses.
- **Personalized—the space should be personalized for students and teachers**
 - Consider alternative and creative colors, sounds, pictures, and videos.
 - Involve students and teachers in making choices to promote personalization.
 - Use things that allow individual control and manipulation by students and teachers.
- **Accessible—the space should be open and easily available for use by all**
 - Use technologies that are easily moved to fit changing needs.
 - Use interactive work surfaces linked to mobile devices and notebooks.
 - Provide affordable access to online digital resources, services, and storage.
- **Collaborative—the space should support collaboration when appropriate**
 - Provide a space to support cooperative learning and group work when those pedagogies are involved.
 - Support relevant local, national, and global networks, partnerships, and learning communities.
- **Engaging—the space should support learning engagement with content, other learners and teachers**
 - Community, professional, and expert engagement.
 - To energize and inspire learners and tutors.
 - Faster, deeper learning.

9.3.3 Examples of Effective Learning Spaces

9.3.3.1 Collaboration Rooms at Texas State University

These new rooms at Texas State University are on Alkek's main floor to the right of the café, behind the marble wall (see Fig. 9.2). Student could bring laptops (Mac & PC compatible) and share screen (see www.library.txstate.edu/about/departments/learning-commons/collaboration-zone.html). The following items indicate how collaboration rooms at Texas State University satisfy some of the design principles mentioned above.

- **Accessible:** According to the introduction about collaboration room, four rooms have tables available with large monitors and power charging capability. Student can use mobile devices and notebooks to share screen.
- **Collaborative:** Collaboration room provides a space to support cooperative learning and group work for local students; furthermore, students can also have a group discussion with global students with the help of network.

9.3.3.2 Beijing National Day School of China

The Beijing National Day School (BNDS), originally a school for children of the Central Military Committee, was established in 1952 and ranks as one of the biggest secondary schools in the urban area of Beijing. BNDS embraces the Maker Movement pedagogy (see <https://makerfaire.com/maker-movement/>) on a large and comprehensive scale. Students design, develop, and market a variety of products associated with various subjects. VR and collaboration are evident throughout the school which typically has laboratories and workplaces rather than traditional classrooms. Sample arrangements of learning spaces at BNDS are presented as



Fig. 9.2 Collaboration room at Texas State University

follows, along with an indication of how these spaces meet the learning space design principles.

The following items indicate how the Beijing National Day School of China satisfies some of the design principles mentioned above (see Figs. 9.3, 9.4 and 9.5).

- **Personalized:** Multi-color learning space stimulates student to learn. Comfortable furniture and soft lighting satisfy students' learning needs.
- **Collaborative:** The maker space and learning commons are flexible space to encourage learners to meet for joint experience such as play, performance, or debate. The maker space can also be used for group presentations and static works associated with academic or curricular programs.
- **Engaging:** The learning commons becomes an extension to the pathways connecting other rooms and a favorite area for studying, meetings, and impromptu gatherings.

Fig. 9.3 Learning commons



Fig. 9.4 Library



Fig. 9.5 Maker space



9.3.3.3 Future Learning Environments in Sweden

This design is part of a project called future learning environments for the Karolinska Institute in Sweden (see <http://www.interiordesign2014.com/architecture/karolinska-institute-future-learning-environments-by-tengbom/>), grounded on research on learning and higher education.

Such facilities are located primarily next to the lecture halls and were initially leftover and deserted areas. The idea is to create a *home away from home*, a natural meeting place for students, teachers, and researchers. The following items indicate how the future learning environment satisfies some of the design principles previously mentioned.

- **Engaging:** The facilities have become a social arena where you hang out and socialize, including a common meeting place and a central information point. The spaces include open squares, room in rooms, and reading areas for focused study.
- **Collaborative:** As a part of the concept of the “Home away from home”, it is a place where you can exchange thoughts and ideas and where peer learning is facilitated.

9.3.3.4 The 101 VR Classroom (A NetDragon Project; See <http://edu.nd.com.hk/zh-hk/product/vreditor>)

With high-quality teaching resources, the 101 VR Classroom integrates virtual reality into teaching and learning, which can create a close-to-real learning environment for students. The 101 VR Classroom is an open, interactive, immerse learning environment with an accompanying editor to allow designers and teachers to create specific learning resources. The 101 VR Classroom has these characteristics as shown in the following two Figs. 9.6 and 9.7.

The following items indicate how the 101 VR Classroom satisfies some of the design principles mentioned above.

Fig. 9.6 101 VR Classroom layout



Fig. 9.7 Fire escape course simulation



- **Sustainable:** integration including e-books, teaching materials, international top education products, 3D teaching resources and other educational resources, through the mobile Internet, education cloud platform, and other technologies, with the global educators and learners to share.
- **Personalized:** In the 101 VR Classroom, the student's vision, hearing and external isolation, completely eliminate the outside interference, and completely devoted into the virtual reality, consequently achieving immerse feeling.
- **Accessible:** The students can obtain the same feeling from the real world as that from the visual, auditory, and tactile devices with the special VR equipment, span the limitation of time space, visualize the concept of abstraction, and experience a highly open, interactive and immerse three-dimensional learning environment.
- **Engaging:** Through the visual, voice, touch, gestures, movements and even the brain waves, such as the combination of "multimode" interactive way, teachers can use VR 101 Assistant, a key device to control the class of VR equipment playback and stop, thoroughly break through the interaction between human-computer interaction, the two-dimensional interaction limitations, so that teachers can deliver more efficient teaching, and students receive more natural and easy learning.

9.4 Smart Learning Environments

9.4.1 Definition of Smart Learning Environments

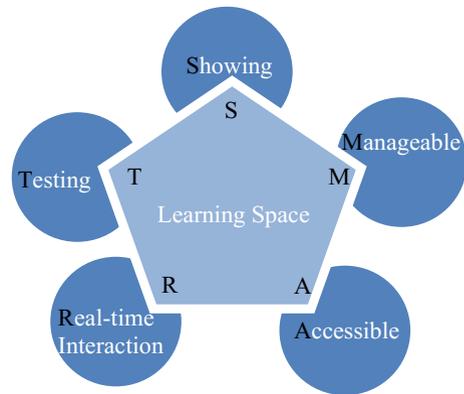
With the development of ICT in education, researchers have begun to conceptualize how learning environments can be made more effective, efficient, and engaging on a large and sustainable scale (Spector, 2014). Smart learning environments (SLE) are defined as physical environments that are enriched with digital, context-aware, and adaptive devices to promote better and faster learning (Koper, 2014). With technology support, smart classrooms become places where teachers and students can have rich and immerse teaching and learning experiences not previously possible. Hwang (2014) presented the definition and criteria of SLE from the perspective of context-aware ubiquitous learning. Hwang (2014) also introduced a framework to address the design and development of SLE to support both online and real-world learning activities (Hwang, 2014) with the following principles:

- (1) Smart learning environments should integrate a physical environment and a virtual environment. In a smart learning environment, the perceptual, monitoring, and regulating functions of a physical environment are further enhanced. The application of augmented reality can create a seamless integration of virtual environment and physical environment.
- (2) Smart learning environments should provide better learning support and services according to the individual characteristics of learners. Smart learning environments emphasize the process record, personalized assessment, and evaluation of effects and content delivery of learners' learning. According to the learner model, it plays a significant role in planning, monitoring, and evaluation in the development learner's learning capabilities.
- (3) Smart learning environments should support on-campus learning and off-campus learning, formal learning, and informal learning. The learners in this situation are not only campus learners, but also all people that have requirements of learning in their work.

9.4.2 Key Features of Smart Learning Environments

In the information age, the classroom environment is changing in ways to optimize learning with new technologies and alternative pedagogical approaches. The smart classroom is one of the significant changes in which the intelligence of classroom involves five dimensions: showing, manageable, accessible, real-time interactive, and testing (see Fig. 9.8) (Huang, Yang, & Hu, 2012).

Fig. 9.8 Concept of the SMART classroom. Adapted from Huang et al. (2012)



- **Showing:** The ways it presents can match learner’s cognitive characteristics. The content presentation mainly characterizes the intelligence classroom information presentation ability, not only requesting the present content to be able to be visible clearly, but also demanding the present content suitable for learner’s cognitive characteristic. These help enhance learner’s understanding and processing of to study materials.
- **Manageable:** The flexible layout supports teaching activities. Environmental management mainly characterizes the layout diversity and management convenience of smart classrooms. All the equipment, systems, and resources of the classroom should have a strong manageability, including classroom layout management, equipment management, physical environment management, electrical safety management, network management.
- **Accessible:** The abundant resources are helpful in transferring various ways of learning into practice. Resource acquisition is mainly characterized with the ability of resource acquisition and the convenience of equipment access in the classroom, involving three aspects of resource selection, content distribution, and access speed.
- **Real-time Interactive:** The deep-level interaction is helpful in discovering problems and providing timely feedback. Timely interaction is mainly characterized by the ability of smart classrooms to support teaching interaction and interpersonal interaction, involving three aspects of facilitation, smooth interaction, and interactive tracking.
- **Testing:** The ability to perceive the physical environment and learning behaviors is the basis for a smart classroom. Situational perception mainly characterizes the perceptual ability of the physical environment and learning behavior of the smart classroom.

9.4.3 The Constituent Elements of Smart Learning Environments

As shown in Fig. 9.9, the constituent elements of smart learning environments include six components resources, tools, learning communities, teaching community, learning ways, and teaching ways.

- Smart learning environments mainly consist of six elements of learning, namely resources, intelligent tools, learning community, teaching community, learning ways, and teaching ways.
- Learners and teachers interrelate and interact with the other four elements in teaching and learning, so as to promote the effective learning of learners. If learning and teaching were removed, smart learning environments cannot be regarded as learning environments.
- The occurrence of effective learning is the mutual result of individual knowledge construction and group knowledge construction. Learning community emphasizes interaction, collaboration, and exchange of learners, while teaching community is a continuum where teachers learn together, work collaboratively to pursue continuing professional development.
- Learning resources and intelligent tools provide support of both learning community and teaching community. The development of learning community and teaching community is inseparable from the mutual effects of resources and tools. All kinds of intelligent tools provide comprehensive support of the “intelligence” of the learning environments. At the same time, learning community and teaching community advance the evolution of resources and tools.

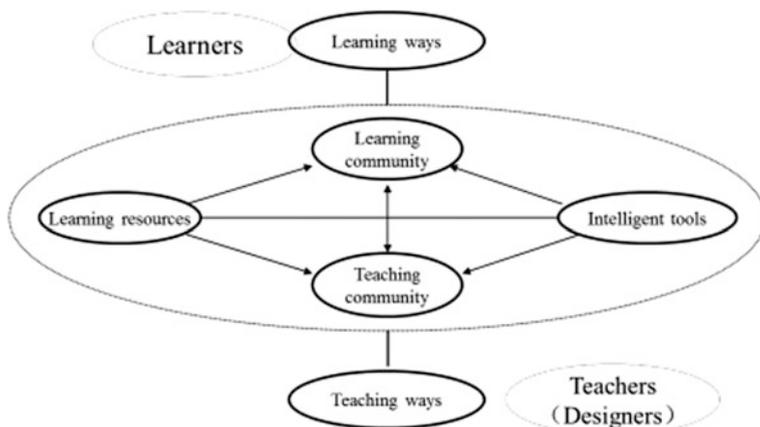


Fig. 9.9 System model of virtual learning space

Main Points in This Chapter

- (1) Learning space refers to a place where teaching and learning occur; it may refer to an indoor or outdoor location, or to a physical or virtual environment.
- (2) The Pedagogy-Space-Technology (PST) framework to describe the connections between pedagogy, technology and the design of a learning space as well as design process includes the three elements of pedagogy, technology, and space.
- (3) SPACE is a broad term to describe guide for the design of new schools, the redevelopment of schools, and the repurposing of buildings and learning spaces to maximize student performance.
- (4) The principles of SPACE include sustainable which means the space should be designed to be sustainable, personalized which means the space should be personalized for students and teachers, accessible which means the space should be open and easily available for use by all, collaborative which means the space should support collaboration when appropriate, engaging which means the space should support learning engagement with content, other learners and teachers.
- (5) Smart learning environments (SLE) are defined as physical environments that are enriched with digital, context-aware, and adaptive devices to promote better and faster learning which can make learning environments more effective, efficient, and engaging on a large and sustainable scale.
- (6) Key features of SLE include showing, manageable, accessible, real-time interactive and testing.
- (7) Six elements of SLE include resources, tools, learning communities, teaching community, learning ways, and teaching ways.

References

- Ellis, R. A., & Goodyear, P. (2016). Models of learning space: Integrating research on space, place and learning in higher education. *Review of Education*, 4(2), 149–191.
- Fisher, K. (2005). Linking pedagogy to space: Proposed planning principles. Department of Education and Training, Victoria, Canada. Retrieved from <https://www.eduweb.vic.gov.au/edulibrary/>.
- Huang, R., Yang, J. A., & Yongbin, H. U. (2012). From digital to smart: The evolution and trends of learning environment. *Open Education Research*, 1(1), 75–84.
- Hwang, G. J. (2014). Definition, framework and research issues of smart learning environments - a context-aware ubiquitous learning perspective. *Smart Learning Environments*, 1(4). Retrieved from <https://link.springer.com/content/pdf/10.1186%2Fs40561-014-0004-5.pdf>.
- Koehler, M., & Mishra, P. (2007). What is technological pedagogical content knowledge. *Contemporary Issues in Technology and Teacher Education*, 9(1). Retrieved from <http://www.citejournal.org/volume-9/issue-1-09/general/what-is-technological-pedagogical-content-knowledge>.

- Koper, R. (2014). Conditions for effective smart learning environments. *Smart Learning Environments*, 1(5). Retrieved from <https://link.springer.com/content/pdf/10.1186%2Fs40561-014-0005-4.pdf>.
- OECD. (2017). Recognition of Non-formal and informal learning. Retrieved from <http://www.oecd.org/education/skills-beyond-school/recognitionofnon-formalandinformallearning-home.htm>.
- Spector, J. M. (2014). Conceptualizing the emerging field of smart learning environments. *Smart Learning Environments*, 1(2). Retrieved from <https://slejournal.springeropen.com/track/pdf/10.1186/s40561-014-0002-7>.