Chapter 13
Improving Learner Experience in the Technology Rich Classrooms

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Abstract With more and more technology equipped in classroom to facilitate teaching and learning, Technology Rich Classroom (TRC) gradually became a hot topic for educational researchers, practitioners, and policy makers, especially when it was looked as one important learning space or learning environment. However, some predicaments had emerged in current multimedia classrooms, which resulted in lower learner experience for the new generation. In this chapter, we first investigated the development and definition of user experience and based on that we defined learner experience in TRC as learners' perceptions and responses that resulted from physical environment changes. Then we proposed the five elements of learner experience: value, usability, adaptability, desirability, comfortability. Finally, considering the connotation and extension of the five elements for learner experience, as well as the factors associated with the equipping and furnishing classroom, we brought forward a framework for analyzing learner experience. We also identified the indicators for evaluating learner experience in TRC by deeply investigating the changing factors of classroom and the five elements of learner experience.

Keywords User experience · Technology rich classrooms · Learning space · Leaner experience · Framework

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13.1 Introduction

Classroom is the most important supporting elements in teaching and learning processes, which is designed by the architect to accommodate various elements such as chair, desk, cupboard, whiteboard, and audio-visual equipment (Udin and Rajuddin 2008). In the mid-1990s, schools began to implement programs to bring technology into the classroom, and with the development of technology and pedagogy, classroom has now been equipped with various technologies to support teaching. The use of desk computer, laptop computer, interactive whiteboard, projector, Internet access, productivity and curriculum-related software, and a printer have enabled great changes of teaching methods and strategies in classroom. The emerging models of "technology enhanced learning environments" (TEAL)—first introduced at MIT in 2003—proposed that acoustics, furniture, lighting (both natural and artificial), mobility, flexibility, air temperature, and security must support the educational technologies being designed for those spaces (Fisher 2010). Since more and more educational researchers have seen the importance of classroom environment and the influences that technologies have played on students' learning in classroom, there have been lots of research and practice to explore the impact of classroom equipment. At the same time, the rapid advances in technology have revolutionized the way in which the children learn, play, communicate, and socialize (Mouza and Lavine 2013). The teaching model must adapt to students' learning preference, and the classroom equipment should support and promote diverse teaching strategies. The classroom equipped with various technologies is always called Technology Rich Classroom (TRC), which has enabled the emergence of a true synchronous/asynchronous and virtual/physical matrix of learning opportunities for which our existing learning environment infrastructure is not well suited for children to learn (Mitchell 2003). In order to study on how to design a TRC, we investigated TRC both at a background of a learning space in supporting social forms of student interaction, and at a background of smart learning environment in response to the "new generation" learners.

13.1.1 Research in Learning Space

Learning spaces are designed to support, facilitate, stimulate, or enhance learning and teaching, which encompass formal, informal, and virtual environments. Learning space involves the intersection of the design of physical and virtual spaces, the appropriate technology with which to populate newly configured spaces and the impact such spaces have on how faculty teach and students learn in them (Lomas and Oblinger 2006; Montgomery 2008). According to the literature, early researchers have been engaged in developing theoretical models, formulating a common terminology, encouraging to rethink pedagogical approaches, and developing effective

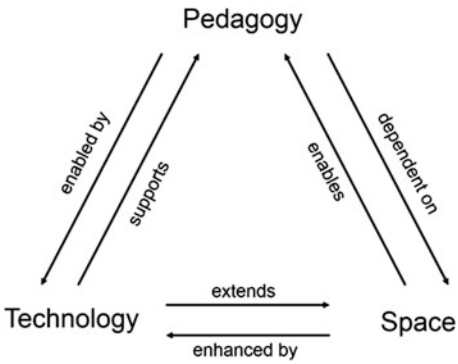

Fig. 13.1 Pedagogy-space-technology (PST) design and evaluation framework

assessment and evaluation tools related to learning spaces (Hunley and Schaller 2009; Jorn et al. 2009; Lippincott 2009).

Radcliffe et al. (2008), a Professor from the Next Generation Learning Spaces group in the University of Queensland, had developed a simple interrogative approach—called the Pedagogy-Space-Technology (PST) Design and Evaluation Framework—to help guide conversation among the disparate members of a building-project team, as shown in Fig. 13.1.

Perkins (2009) proposed a framework which clearly placed the individual learner at the center of the teaching and learning process, as shown in Fig. 13.2. In conjunction with the desired new knowledge and ways of working, the learner drove the learning agenda where the digital technology, digital pedagogy, and twenty-first century learning spaces were dependent elements meeting the individual needs. This theoretical framework, presented as a Venn diagram, also offered some notable "intersections" for consideration, particularly between spaces-technology and spaces-pedagogy.

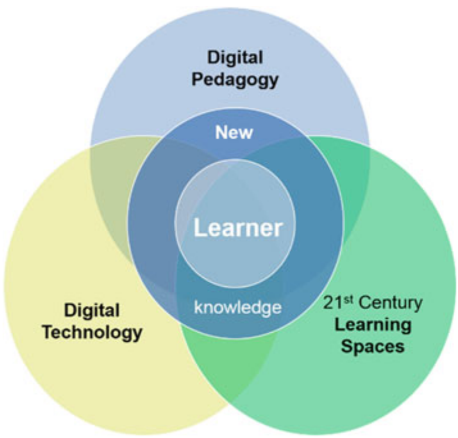

Fig. 13.2 Framework of twenty-first century learning spaces

Learning space is a new emerging research area, with the aim to promote independent, flexible, and engagement learning by providing leaner appropriate technology and pedagogy. The core value of constructing learning space is to prepare today's students for tomorrow's environment, and to enable learners to adapt in the future work and life. Learning space research includes the planning, design, implementation, and evaluation of all spaces for learning. The United States and the United Kingdom and other developed countries have made useful attempts, and Australia has implemented several successful programs on learning space with the Government's support.

13.1.2 TRC as a Learning Space

Classrooms, which have engendered a host of conversations, were by far the single most important space for learning (Brown 2005). Technology Rich Classroom is always considered as a learning space and the principles for building learning space could be used for building a TRC. In practical field, several research projects were carried out and their implications had been assimilated by the academic community.

The Massachusetts Institute of Technology started Technology Enabled Active Learning (TEAL) project incorporated a redesign of both course approaches and the space to facilitate student interaction and problem solving by employing round student tables, laptop connections, display screens, marker boards, software-based simulations and visualizations. Dori and Belcher (2005) implemented a quasi-experimental design and found that students in the TEAL programs had lower failure rates and higher rates of conceptual understanding than students taking the course in a traditional environment with a lecture-based approach.

North Carolina State University initiated Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) to enhance in-class problem solving and increase faculty–student interaction by employing large round tables for students, laptop connections, projectors, pedagogical approach, and teaching materials for cooperative learning. Beichner et al. (2007) found that the top tier of students increased levels of conceptual understanding, and both the overall and at-risk student improved problem-solving skills, attitudes, and class attendance rates.

University of Minnesota built Active Learning Classrooms (ALC) with round tables for nine students, switchable laptop technology for presenting student' work, two large projector screens for displaying teaching materials. By a quasi-experimental research, Brooks (2012) indicated that (1) space shapes instructor behavior and classroom activities; (2) instructor behavior and classroom activities shape on-task student behavior; therefore, (3) space shapes on-task student behavior.

The analysis of projects on TRC showed that the fusion of technology, pedagogy and space has changed learning behavior and teaching behavior. However, the emphasis of TRC research and practice mainly focused on the design method, and the evaluation methods were always missed in the research. Especially, with the emerging technologies equipped in TRC, such as tablet PC, wireless communication, multiscreens projectors, and e-textbooks, as well as flexible furniture layout, a new perspective for evaluating TRC should be developed.

13.1.3 Research on Smart Learning Environment

Today's learners differ from those of learner even 10 years ago in attitudes, expectations, and constraints. (Oblinger 2006) Many of today's learners favor active, participatory, experiential learning; they are also highly social, connecting with friends, family, and faculty face-to-face and online; they appear to have no fear of technology (Shinde et al. 2012).

Based on the demands of new generation of students for the reform of learning environment and the analyzing of challenges for both the online learning environments and classroom former environments, Huang et al. (2012) proposed the concept of "smart" learning environment which is the high level of digital learning environment with the aim at facilitating "easy, engaged and effective" learning for learners. After analyzing the differences of smart learning environment and digital learning environment from learning resources, learning tools, learning communities, teaching communities, ways of learning, and ways of teaching, they put forward a system model and TRACE[3] functional model of "smart" learning environment, which stands for tracking, recognizing, awareness and connecting for promoting easy, engaged and effective learning (Huang et al. 2012).

The background for emerging of "Smart Learning Environment" is the predicaments of current learning environments in formal educational settings. The current learning environment only supports the low-order cognitive objectives, such as knowledge, comprehension, and application, while not supporting higher-order cognitive objectives, such as analysis, synthesis, and evaluation. First, in a multimedia classroom, instructors present their teaching content with serialized presentations, which hinders students' understanding of the learning content. Second, multimedia consoles are always fixed in the front of the classroom, which limits the flexibility of teaching. Third, a unified and fixed seating layout is not conducive for teachers to carry out diverse teaching activities. Fourth, computer-networked classroom's equipment does not meet the needs of the students' inquiry learning. Fifth, a gap exists between teaching with electronic whiteboard applications and expectations of deeply interactive teaching. All these factors result in that students don't have a good experience while they study at classroom.

13.2 The Concept of Learner Experience

Experience in using a product or object exists in our daily lives. We perform activities with them, e.g., a knife to cut an apple; we express part of our identity with them, e.g., wrist watches; and we use them as a medium to interact with other people, e.g., mobile telephones. In 1940s, UX was raised in the field of human-–computer interaction with the foundation of usability and user-centered design (UCD). The connotation of UX was brought to wider knowledge by Norman et al. (1995), who is a user experience Architect in the mid-1990s. Recent advances in mobile, ubiquitous, social, and tangible computing technologies led to a shift away from usability engineering to a much richer scope of user experience, where users' feelings, motivations, and values are given as much attention than efficiency, effectiveness, and basic subjective satisfaction (Wikipedia 2013).

Up to now, more than 30 influential definitions of UX have been raised by the academic community, including some international organizations and companies such as Wikipedia, Microsoft, W3C, etc. Existing definitions are different as they are defined from different context, however, most of them mainly focused on product, system, and services. In the perspective of "product", user experience refers to the experience that a person gets when he/she interacts with a product in particular conditions. In practice, there are numerous different kinds of people, products, and environments that influence the experience that interaction evokes. (Alben 1996; Arhippainen and Tähti 2003; Desmet and Hekkert 2007) In the perspective of "system", user experience is about how a person feels about using a system (Wikipedia 2013), which highlights the experiential, affective, meaningful, and valuable aspects of human-computer interaction (HCI) and product ownership.

As devices, products, software systems, and services are included in experience when learning happened in TRC, it is important to see learner experience in a macro view to include all the aspects of experience. User experience was defined as "a person's perceptions and responses that result from the use or anticipated use of a product, system or service" by ISO (2009), which is the most closed definition to the concept of learner experience that stands for the user experience to educational products or environments, especially in a new classroom.

In a healthy classroom learning environment, the student, teachers, and designers will be turning to concepts of sustainable design to address comfort-related issues such as hygiene, safety, acoustics, and availability of space, natural daylight, and natural ventilation (OECD 2006). For a TRC, the learning technology in classroom encompasses virtual technologies, such as online presence and online resources, installed appliances, such as media presentation systems, remote interaction systems and room-scale peripherals, and mobile devices (Milne 2006). So the user experience in a TRC includes the experience of learner in using new classroom furniture, equipment and device, software system, and services.

Therefore, we can define Learner Experience in a TRC as learners' perceptions and responses that result from physical environment changes, such as decorating classroom and changing layout, equipping by providing audio-visual system, computers, devices, and software, and services in gaining technologies gradually involved for learning.

13.3 Elements of Learner Experience in TRC

The structure and elements of user experience can reveal the connotation and extension for the definition, which could enlighten us the structure and elements of learner experience in TRC. Morville (2004) proposed a conceptual framework, which is called User Experience Honeycomb as shown in Fig. 13.3, to describe the elements of UX in designing websites.

In order to create a meaningful and valuable user experience, the information in a website must be: (1) Useful: content should be original and fulfill a need; (2) Usable: website must be easy to use; (3) Desirable: image, identity, brand, and other design elements are used to evoke emotion and appreciation; (4) Findable: content needs to be navigable and locatable onsite and offsite; (5) Accessible: content needs to be accessible to people with disabilities; (6) Credible: users must trust and believe what you tell them; (7) Valuable: website must deliver value to our sponsors.

Rubinoff (2004) proposed that user experience is made up of four interdependent elements: branding, usability, functionality, content. Branding includes all the esthetic and design-related items within a Website. It entails the site's creative projection of the desired organizational image and message. Functionality includes all the technical and "behind the scenes" processes and applications. It entails the site's delivery of interactive services to all end users, and it's important to note that this sometimes means both the public as well as administrators. Usability entails the general ease of use of all site components and features. Subtopics beneath the usability banner can include navigation and accessibility. Content refers to the actual content of the site (text, multimedia, images) as well as its structure, or information architecture. We look to see how the information and content are structured in terms of defined user needs and client business requirements.

To help define the objectives and scope of user experience efforts, as well as enable their meaningful measurement, Guo (2012) suggested a conceptual framework that describes four distinct elements of user experience, including value, usability, desirability, and adoptability, and how they interact with one another in driving better product designs, as shown in Fig. 13.4.

Learner experience in a TRC needs to consider classroom as an integrated system with classroom furniture, equipment and devices, software systems, and services. The four elements of user experience for products can be used to express the learner experience in a TRC. While, learner experience should consider the diversity of learners in learning environment, so we use "Adaptability" to replace "Adoptability" to show the diversity needs from students. Also, the physical environment factors, such as light, temperature, and acoustics, play an important role for experience. So "comfortability" is also included in learner experience. Through the above analysis, the elements of learner experience include value, usability, adaptability, desirability, comfortability, as is shown in Fig. 13.5.

Fig. 13.3 User experience honeycomb (for designing websites)

Fig. 13.4 Four elements of user experience (for products)

Value Is it useful?	**Usability** Is it easy to use?
Adoptability Is it easy to start using?	**Desirability** Is it fun and engaging?

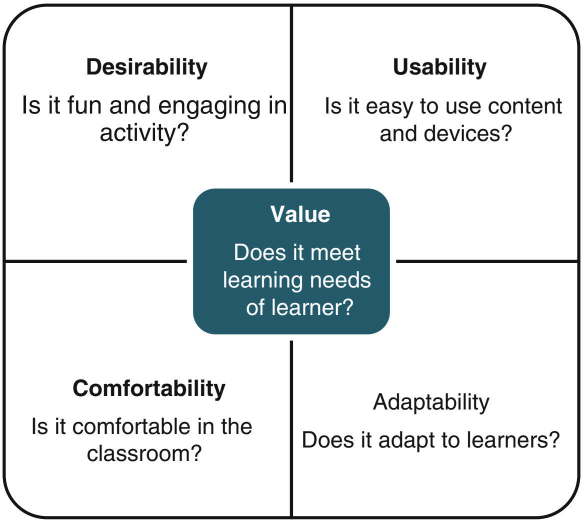

Fig. 13.5 Five elements of learner experience in TRC

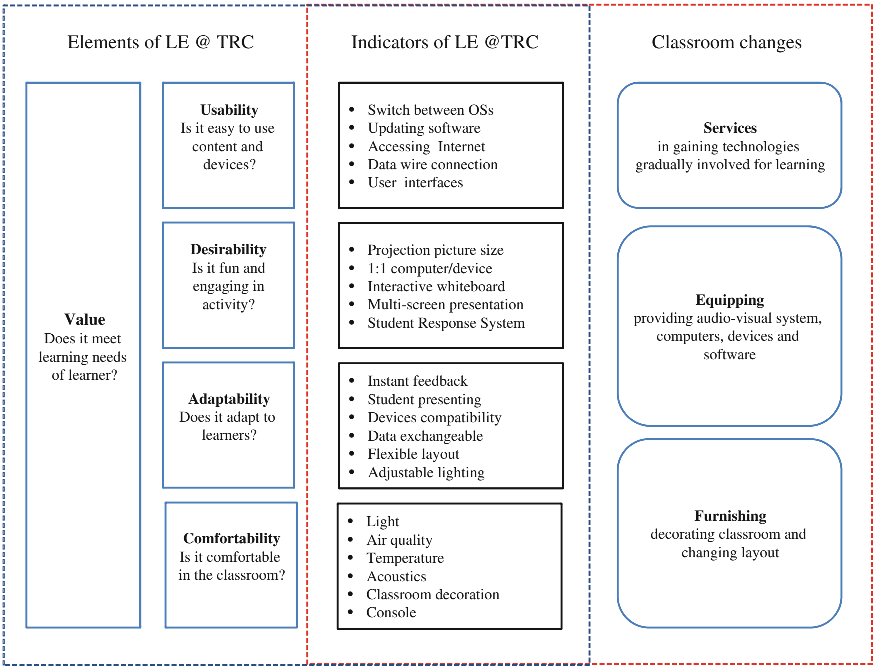

Fig. 13.6 Framework for analyzing learner experience in TRC

13.4 Indicators to Evaluate Learner Experience in TRC

Learner experience in TRC could be designed, improved, and evaluated by considering the connotation and extension of the five elements of learner experience, as shown in Fig. 13.5 the framework for analyzing Learner Experience in TRC. Value is the most core indicator for learner experience, and other four elements should support it. Services, equipping and furnishing are the main factors in a TRC changes, of which the indicators of learner experience derived from (Fig. 13.6).

13.4.1 Value: Does It Meet Learning Needs of Learner?

From the holistic perspective, value of learner experience refers to the positive or negative quality that renders the changes of classroom, such as classroom furnishings and layout changes, the use of equipment, desirable or valuable for the learners.

What drives a TRC's value to learner? TRC features must be in alignment with learning needs. If a classroom change is designed to support learning needs, teacher and learners may consider the layout changes and equipment valuable. Learning needs encompass more than just their explicit needs—things that learner know they want, but to include learners' implicit needs—things that learners don't express as needs, which might be hidden in learning activities and be recognized by their teacher. In order to meet learners' unexpressed needs, TRC should not only be easy-to-use products, such as devices and software, but also services that add much value to student learning.

13.4.2 Usability: Is It Easy to Use Content and Devices?

Usability refers to the ease of use and learnability of a TRC, which is composed of: (1) learnability: how easy is it for teachers and students to accomplish basic tasks the first time they encounter the TRC, (2) efficiency: once teachers and students have learned the design of a TRC, how quickly can they perform teaching and learning tasks? (3) Memorability: when teachers and students return to the design after a period of not using it, how easily can they establish proficiency? (4) Errors: how many errors do teachers and students make, how severe are these errors, and how easily can they recover from the errors? (5) Satisfaction: how pleasant is it to use the design?

The design factors of a TRC include systems, facilities, and software which have a significant influence on usability. Operating Systems provide a software platform for the application programs to run. Microsoft Windows, Mac OS X, GNU/Linux are examples of popular modern operating systems being used in personal computers (Ukessays 2013). Operating Systems, with diverse features, provide different software to support different resources and learning activates. The facilities include devices, audio-video control system, projector, interactive whiteboard, student response system, access of wireless network, etc. Software systems include learning management systems, resources providing system, collaborative learning platform. Classroom network tools offer new possibilities for classroom interaction; they present ways of rapidly distributing information, exchanging ideas, and constructing shared artifacts that can support a variety of engaging and mathematically rich activities that would be difficult or impossible to implement in conventional classrooms (White 2013). Within the context of learning tasks, a large part of desirability is attributable to innovative and recognizable design in user interface and interaction. User interface design includes well-organized navigation, nice looking graphics, and sleek designs. Meanwhile, interaction design includes the convenient, smooth, and multiple operations. More important, a desirable TRC must engage learner in relation to their purpose of using.

Based on the above analysis, we proposed the following indicators for evaluating usability in a classroom. (1) Is it easy to switch to a different Operating System? (2) Updating software with new version appearing frequently. (3) Is it easy to access to Internet? (4) Are data wires available for connecting different types of devices, such as USB, AV, VGA, HDMI, etc.? (5) Are the user interfaces friendly?

13.4.3 Desirability: Is It Fun and Engaging in Activity?

Desirability in a TRC refers to the attractiveness and engagement of the activities in a TRC or the pleasing perception from teachers and students. A pervasive goal in education is to engage students in learning so that they are attentive and mindful (Lavigne and Mouza 2013). Engagement involves three dimensions (Fredricks et al. 2004): (a) behavior (e.g., participation in activities such as number of times students interact with virtual world characters, embedded tools, objects), (b) cognitive-motivational (e.g., putting forth effort, belief of competence in content area or self-efficacy, desire to be optimally challenged), and (c) emotions (e.g., interest, curiosity, sense of belonging, and affect). Engagement in a TRC depends on the content presentation methods, the digital resource, software systems, and interactive design.

Vahey et al. (2013) leverage four key benefits of using dynamic-representation environments in mathematics classrooms: (a) providing multiple representations for student understanding, (b) providing a shared focus of attention, (c) supporting the use of narrative as a representation, and (d) engaging students in the mathematics. Dynamic-representational environments have also been shown to increase student engagement in mathematics. Focusing on young children's collaborative communication and thinking in classroom science activities, Kershner et al. (2010) suggests that the IWB can be used collaboratively in a variety of science activities closely related to familiar classroom practice and the children can engage effectively in the collective learning experience. The research on multi-image presentation revealed that multiscreen presentation having split-attention effect followed the cognitive load theory, which means that learners obtain better learning performance by integrated information (Ayres and Sweller 2005).

Therefore, the indicators for desirability in a TRC could include the following aspects: (1) Does the size of projector screen match the classroom? (2) Do 1:1 computers/devices match the content? (3) Do interactive whiteboard match the activities? (4) Is the content presented on the screen using multiscreen technology? (5) Does Student Response System provide active learning?

13.4.4 Adaptability: Does It Adapt to Learners?

Adaptability for a TRC mainly deals with the diversity of students and their learning preferences. In order to meet the diverse needs of students, room layout should be flexible to meet the teacher's instruction and learner's collaboration, software system should adapt to learning styles of the learners, and physical environment factors, such as the lighting, temperature, ventilation, could be adjusted automatically.

Hill (2008) recognized that flexible, modern learning environments could encourage students to fully participate in activities with others as they acquire knowledge for themselves. With regard to classroom layout, Lippman (2002, 2003) in his study of schools mentions that providing a variety of spaces within a classroom supports student–teacher/child–adult relationships. Jamieson (2007) recognized that formal spaces such as lecture theaters, classroom, and labs should have flexible layouts that support a diversity of teaching and learning approaches.

From the above analysis, combined with considering the emerging technology equipped in TRC and the main furnishing elements, we proposed the indicators for evaluate the adaptability of a TRC could include the following aspects: (1) Does the software system provide instant feedback? (2) Can students present and share their learning outcome easily (3) Are the systems compatible with common devices? (4) Does data between the student and teacher change easily? (5) Is the classroom layout flexible for different learning activities? (6) Can the lighting system adapt to learners needs with the changes of nature light?

13.4.5 Comfortability: Is It Comfortable in the Classroom?

Comfortability in TRC relates to providing or experiencing TRC's physical well-being, i.e., the user interface and environmental conditions consisting of various elements such as temperature, humidity, noise, thermal, air pressure, ventilation, air quality, acoustic, dust, vibration, lighting, air flows, radiation, etc.

Due to the increased use of media and technology in classrooms, the design of easy-to-use, adjustable lighting systems is more important than ever. Lighting should be designed in accordance with the Illuminating Engineering Society's and the National Electrical Code's current recommendations. Lighting should be designed to meet the special program requirements for each instructional space (Clabaugh 2004). In addition, many studies showed that the following factors are important design considerations (Filardo and Vincent 2010): (1) Indoor air quality (IAQ)—mold and airborne bacteria have adverse effects on children's and teachers' health. (2) Temperature and humidity—creates conditions which lead to Sick Building Syndrome, relative absenteeism and lowered mental acuity. (3) Ventilation and air flow—is an occupational health and safety issue because children require more air in proportion to their body weight than adults. Studies indicate that air flow from windows is inadequate in schools to remove or prevent the buildup of carbon dioxide. Poor air flow leads to poor performance of tasks. (4) Thermal comfort—there is an optimum temperature for learning, retention, task performance, and job satisfaction. (5) Acoustics—good acoustics (quality rather than amount of noise) are fundamental to academic performance. (6) Building age, quality, and esthetics—affect student and teacher perceptions of safety and well-being. Building age is not as important as the quality of building conditions. Students generally perform better in modernized or new environments but it is difficult isolating mediating factors, and therefore, inconclusive. (7) Furniture and carpets—dampness and pollutants can lead to health problems, e.g., asthma.

Based on the important factors for comfortability in a classroom, we proposed the following indicators for evaluating classroom comfortability. (1) Does the lighting system support reading healthy? (2) Does air in the classroom meet the air quality standard? (3) Is the temperature in the classroom suitable for learning? (4) Does the classroom have good acoustics? (5) Does classroom decoration meet the students' preference? (6) Is the teaching console easy to operate?

13.5 Conclusion

New generation of learners appeals for technology-rich, flexible, and comfortable learning space. TRC as a learning space should consider the new generation student's needs. Considering the digital learner's needs, we proposed the concept of "learner experience" to show learners' perceptions and responses that result from physical environment changes. With the fusion of technology, pedagogy, and space, learner experience in a TRC gradually became important for ensuring students' engagement and performance.

We proposed value, usability, adaptability, desirability, and comfortability as the five elements in a TRC that will influence learner experience, which should be considered when build or rebuild learning space. Learner experience will change when the Furnishing (providing audio-visual system, computers, devices, and software) and Equipping (decorating classroom and changing layout) in a TRC changed, and service was one of the most key factors for improving learner experience in a TRC. The framework for analyzing Learner Experience in TRC we proposed in this chapter presented the most important factors for improving students' experiences in a TRC, which could become the guideline for optimizing classroom environment supported by technology. It is believed that the framework for analyzing learner experience will become a significant direction in learning space design and evaluation, but the framework we proposed were not perfect and should get improved in future.

The indicators in the framework for analyzing Learner Experience in TRC indicated the detail information for each element, which will help designers and practitioners to build an advanced TRC for learner. However, these indicators were yet in the rough and should be refined and enriched with more empirical study. The next step of this research should be (1) to develop the scales for measuring learner experience in TRC; (2) to investigate the relationship between learner experience and students' performance; (3) to test and verify the framework for analyzing Learner Experience in TRC by cross-cultural collaborative empirical study.

References

Alben, L. (1996). Quality of experience: Defining the criteria for effective interaction design. *Interactions, 3*(3), 11–15.

Arhippainen, L., & Tähti, M. (2003). Empirical evaluation of user experience in two adaptive mobile application prototypes. *Proceedings of the 2nd International Conference on Mobile and Ubiquitous Multimedia* (MUM 2003), Norrköping, Sweden.

Ayres, P., & Sweller, J. (2005). The Split-Attention Principle in multimedia Learning. In R. E. Mayer (Ed.), *The Cambridge Handbook of Multimedia learning* (pp. 135–158). New York: Cambridge University Press.

Beichner, R., Saul, J., Abbott, D., Morse, J., Deardorff, D., Allain, R., et al. (2007). Student-centered activities for large enrollment undergraduate programs (SCALE-UP) project. In E. Redish & P. Cooney (Eds.), *Research-based reform of university physics* (pp. 1–42). College Park: American Association of Physics Teachers.

Brooks, D. C. (2012). Space and consequences: The impact of different formal learning spaces on instructor and student behavior. *Journal of Learning Spaces*, *1*(2).

Brown, M. (2005). Learning spaces. *Educating the net generation*, 12–1. Washington: Educause.

Norman, D., Miller J., & Henderson, A. (1995). What you see, some of what's in the future, and how we go about doing it: HI at Apple Computer. *Proceedings of CHI 1995*, Denver, Colorado.

Dori, Y., & Belcher, J. (2005). How does technology-enabled active learning affect undergraduate students' understanding of electromagnetism concepts? *The Journal of the Learning Sciences, 14*, 243–279.

Filardo, M., & Vincent, J. (2010). Research on the impact of school facilities on students and teachers: A summary of studies published since 2000. *Educational Facility Planner, 44*(2), 25–27.

Fisher, K. (2010). *Technology-enabled active learning environments: An appraisal* (No. 2010/7). Paris: OECD Publishing.

Guo, F. (2012, September 18). More than usability: The four elements of user experience [Web log message]. Retrieved from http://www.uxmatters.com/mt/archives/2012/04/more-than-usability-the-four-elements-of-user-experience-part-i.php.

Hill, F. (2008). Patterns for small learning communities at the elementary level: The "L" shaped classroom. Retrieved from http://www.schoolfacilities.com/uploads/files/85.pdf.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*, 59–109.

Huang, R., Hu, Y., Yang, J., & Xiao, G. (2012a). The functions of smart classroom in smart learning age. *Open Education Research, 18*(2), 22–27.

Huang, R., Yang, J., & Hu, Y. (2012b). From digitalized environment to smart environment: The reform and trends of learning environment. *Open Education Research, 18*(1), 12–24.

Hunley, S., & Schaller, M. (2009). Assessment: The key to creating spaces that promote learning. *EDUCAUSE Review, 44*, 26–35.

ISO FDIS 9241-210 (2009). Ergonomics of human system interaction—Part 210: Human-centered design for interactive systems (formerly known as 13407). *International Organization for Standardization* (ISO). Jithin Dev.

Jamieson, P. (2007). *Rethinking the university classroom: Designing 'places' for learning*. Paper presented at the Next Generation Learning Space Conference.

Jorn, L., Whiteside, A., & Duin, A. (2009). PAIR-up. *EDUCAUSE Review, 44*, 12–15.

Kershner, R., Mercer, N., Warwick, P., & Kleine Staarman, J. (2010). Can the interactive whiteboard support young children's collaborative communication and thinking in classroom science activities? International Journal of Computer-Supported Collaborative Learning, 5 (4) 359–383.

Perkins, J. (2009, September 18). Enabling 21st century learning spaces [Web log message]. Retrieved from http://jperk30.edublogs.org/2009/11/07/enabling-21st-century-learning-spaces/.

Lavigne, N. C., & Mouza, C. (2013). Epilogue: Designing and integrating emerging technologies for learning, collaboration, reflection, and creativity. In *Emerging technologies for the classroom* (pp. 269–288). New York: Springer.

Lippincott, J. (2009). Learning spaces: Involving faculty to improve pedagogy. *EDUCAUSE Review, 44*, 16–25.

Lippman, P. C. (2002, October). Understanding activity settings in relationship to the design of learning environments. *CAE Quarterly Newsletter*. AIA Committee on Architecture for Education.
Lippman, P. C. (2003, September). Advancing concepts about activity settings within learning environments. *CAE Quarterly Newsletter*. AIA Committee on Architecture for Education.
Lomas, C., & Oblinger, D. (2006). Student practices and their impact on learning spaces. In D. Oblinger (Ed.), *Learning spaces* (pp. 5.1–5.11). Washington: Educause.
Milne, A. J. (2006). Designing blended learning space to the student experience. *Learning spaces*, 11–1.
Mitchell, W. (2003). *21st Century learning environments*. Presentation at a workshop on new learning environments at Queensland University of Technology in conjunction with K. Fisher.
Montgomery, T. (2008). Space matters: Experiences of managing static formal learning spaces. *Active Learning in Higher Education, 9*, 122–138.
Mouza, C., & Lavigne, N. (2013). Introduction to emerging technologies for the classroom: A learning sciences perspective. In *Emerging technologies for the classroom* (pp. 1–12). New York: Springer.
Oblinger, D. G. (2006). 'Space as a change agent'. In D. G. Oblinger (Ed.), *Learning Spaces* (pp. 1.1–1.4). Washington: Educause.
OECD. (2006). 21st Century Learning Environments. Retrieved from http://mphs.wikispaces.com/file/view/21st+Century+Learning+Environments+-+OECD.pdf.
Morville, P. (2004, September 28). User experience design [Web log message]. Retrieved from http://semanticstudios.com/publications/semantics/000029.php.
Radcliffe, D., Wilson, H., Powell, D., & Tibbetts, B. (2008). Designing next generation places of learning: Collaboration at the pedagogy-space-technology nexus. *The University of Queensland*.
Desmet, P., & Hekkert, P. (2007). Framework of product experience. *International Journal of Design, 1*(1), 57–66.
Rubinoff, R. (2004, September 28). How to quantify the user experience [Web log message]. Retrieved from http://www.sitepoint.com/quantify-user-experience/.
Shinde, S., Shinde, D., & Pune, I. (2012, November). Evaluation of Canadian academic libraries' mobile sites. In *NILIS Symposium* 2012 (p. 59).
Clabaugh, S. (2004). Classroom design manual: Guidelines for designing, constructing, and renovating instructional spaces at the University of Maryland. Retrieved from http://www.it.umd.edu/tc/UM_Classroom_Design.pdf.
Udin, A., & Rajuddin, M. R. (2008, November 25–27). Physical environment in school setting: Conceptual reviews. In *Seminar Penyelidikan Pendidikan Pasca Ijazah* 2008, 25–27 November 2008, University Teknologi Malaysia.
Vahey, P., Knudsen, J., Rafanan, K., & Lara-Meloy, T. (2013). Curricular activity systems supporting the use of dynamic representations to foster students' deep understanding of mathematics. In *Emerging technologies for the classroom* (pp. 15–30). New York: Springer.
White, T. (2013). Networked technologies for fostering novel forms of student interaction in high school mathematics classrooms. In *Emerging technologies for the classroom* (pp. 81–92). New York: Springer.
Wikipedia. (2013, October 8). User experience. [Web log message]. Retrieved from http://en.wikipedia.org/wiki/User_experience.

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