

## Extending Students' learning Spaces: Technology-Supported Seamless Learning

Wenli Chen, Peter Seow, Hyo-Jeong So, Yancy Toh, & Chee-Kit Looi

National Institute of Education, Nanyang Technological University, 1 Nanyang Walk, Singapore 637616

Email: [wenli.chen@nie.edu.sg](mailto:wenli.chen@nie.edu.sg), [peter.seow@nie.edu.sg](mailto:peter.seow@nie.edu.sg), [hyojeong.so@nie.edu.sg](mailto:hyojeong.so@nie.edu.sg), [yancy.toh@nie.edu.sg](mailto:yancy.toh@nie.edu.sg),  
[cheekit.looi@nie.edu.sg](mailto:cheekit.looi@nie.edu.sg)

**Abstract:** Learning is interweaved into and across students' everyday life activities. Technology that is used to support learning should be integrated with everyday life in the same way that learning occurs in everyday life: seamlessly. Mobile technologies, with their reduced size and ease of use, provide the potential to extend students' learning spaces and enrich the learning experiences in their daily lives where they move between locations, switch from one topic or context to another, and interact with different social groups. This paper proposes mobile technology-supported seamless learning and presents learning scenarios from our research to illustrate how learning occurs seamlessly across time and places mediated by mobile devices.

### Introduction

Learning is interweaved into and across students' everyday life activities such as watching videos, browsing Internet, reading book, playing sports, talking to people, and shopping. These activities can be resources and contexts for learning which should be seen not as a shell that surrounds the learner at a given time and location, but as a dynamic entity, constructed by the interactions between learners and their environment (Sharples, Taylor, & Vavoula, 2007). Looi, Seow, Zhang, So, et al (2009) state that the learning space is no longer defined by the 'class' constrained by scheduled class hours or specific locations, but by 'learning' across spaces as they harness ideas and learning resources gained in one location or context, and apply or develop them in another. They learn across time, by revisiting knowledge that was gained earlier in a different context. They learn by moving from topic to topic, managing a range of personal learning projects, rather than following a single curriculum (Sharples, Taylor, & Vavoula, 2007). They learn across social groups, by co-constructing knowledge with another student, a small group, or a large online community, with the possible involvement of teachers, friends, relatives, experts and members of other supportive communities.

Technology that is used to support learning should be integrated with everyday life in the same way that learning occurs in everyday life: seamlessly. Mobile technologies offer the potential for a new phase in the evolution of technology-enhanced learning, marked by a continuity of the learning experiences across different contexts. Chan, Rochelle, Kinshuk and Sharples et al. (2006) use the term "seamless learning" to describe the situations where students can learn whenever they want to in a variety of scenarios and that they can switch from one scenario to another easily and quickly using their personal mobile device as a mediator.

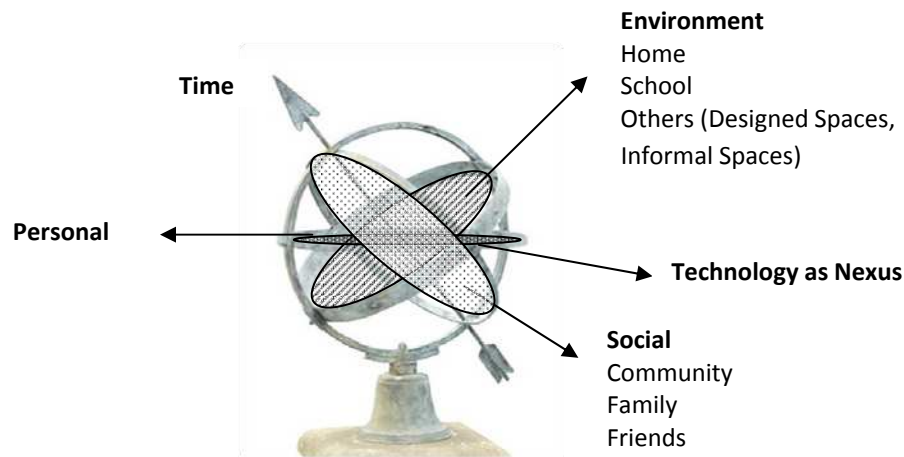
While there is growing recognition that learning can take place anywhere and anytime beyond the walls of classrooms, until recently learning across spatial and temporal spaces has remained an under-researched area. We are conducting a 3-year project designing and investigating a seamless learning environment to bridge Primary (Elementary) students' different learning spaces by equipping them with personal mobile devices. In this paper, we explore how to use mobile technology to support seamless learning and present learning scenarios from our research to illustrate how students use mobile technologies to extend their learning spaces.

### Seamless Learning Supported by Mobile Technology

The basic premise of seamless learning is that it is not feasible to equip students with all the knowledge and skills they need to have for lifelong learning based on snapshots of episodic time frame, location or scenario. Therefore, students will need to continually enhance their knowledge and skills, in order to address immediate problems and to participate in a process of continuous learning. We consider student learning as moving beyond the acquisition of content knowledge to developing the capacity to learn seamlessly.

As the use of mobile technology such as the Smartphone is becoming more pervasive in our lives, we envision learning to occur when a learner interacts with others and the environment across time and location seamlessly through the use of the technology as a mediating tool. Moving away from the Cartesian perspective

where the learner is separated from the world, we view the learner as an active participant in the world. Learning occurs through the rich social interactions with others and interactions with environment as shown in Figure 1. Learning is developmental and occurs through the interactions a learner may experience at different points of time. Technology is a nexus connecting the learning experiences of the learner.



**Figure 1.** Technology supported seamless learning

Stroup and Petrosino (2003) categorize educational technology into two types: vertical technology and horizontal technology - vertical technology is mainly for teachers' needs in a confined setting whereas horizontal technology is used to meet students' personal needs across multiple physical contexts. Many of today's educational technologies are used as vertical technologies in the classroom. Seamless learning requires horizontal technologies that can meet students' personal needs. Mobile technology is exactly a horizontal technology because of its affordances. The characteristics of mobile technologies are well suited to support seamless learning (Chen, Seow, So, Toh, & Looi, in press). The small size and light weight of mobile devices mean that they can be taken to different sites or moved around within a site, so that they can be available wherever the student needs to learn. The use of the mobile device becomes a routine practice and is assimilated into everyday life experiences. Equipping with mobile technologies, students can learn across time and location. The learning experience supported by mobile technology is unobtrusive -it enables students' data exchange, communication and collaboration with teachers, experts, friends and family members etc. As the mobile device can be turned on and off instantaneously, students can use it whenever they need to, enabling them to make rapid connections between ideas and observations. The mobile device can both gather and respond to information specific to the current location, environment and time. This help student learn in real context.

Besides, mobile technology accommodates versatile learning activities. Students can type, draw, take photos, do audio or video recording, supporting their multi-modal expressions. The artifacts created by students can be saved. The student's personal accumulation of resources and knowledge is persistent and can be made immediately accessible by others. The use of the device is adapted to the learner's evolving abilities, skills, knowledge and learning styles and designed to support individualized learning, rather than general office work.

Some of the requirements of technology to support seamless learning can be satisfied by traditional tools such as notebooks, pencils, textbooks, timetables, and diaries etc. However, mobile technologies can supplement these by offering learners the opportunity to manage their learning over time, to engage in collaboration, and to relate information to situated problems. In sum, it is a *learning hub* for the students to engage in several learning activities across time and location by using the same devices.

In our research, each student is equipped with a HTC Tytn II Windows Mobile Smartphone that came with photo-taking function, stylus pen, keyboard, 3G-enabled Internet surfing data plan and educational applications. The students used the Smartphones in class and were allowed to bring home the devices. With the 3G-enabled Smartphone, they have instant access to the Internet inside and outside school at anytime. The students were trained in the basic use of the Smartphone such as the camera, internet connectivity, web browsing and GoKnow Mobile Learning Environment (MLE). GoKnow's MLE is a suite of educational mobile applications comprising Sketchy for creating animated drawings, PicoMap for creating concept maps, iKWL for creating KWL, and MyProjects for students to carry out their learning activities.

## Research Design

Our research is guided by the following research questions: 1) How does the appropriate use of mobile technologies mediate planned and emergent learning inside and outside school? 2) How do students learn seamlessly across the boundaries of learning spaces? and 3) How do we design for learning to occur seamlessly across the boundaries? To answer our questions, we studied an experimental Primary (Elementary) Grade 3 (P3, with nine-year old students) class comprising 39 students and worked closely with the class form and science teacher. The students have been using the HTC Smartphones since March 2009.

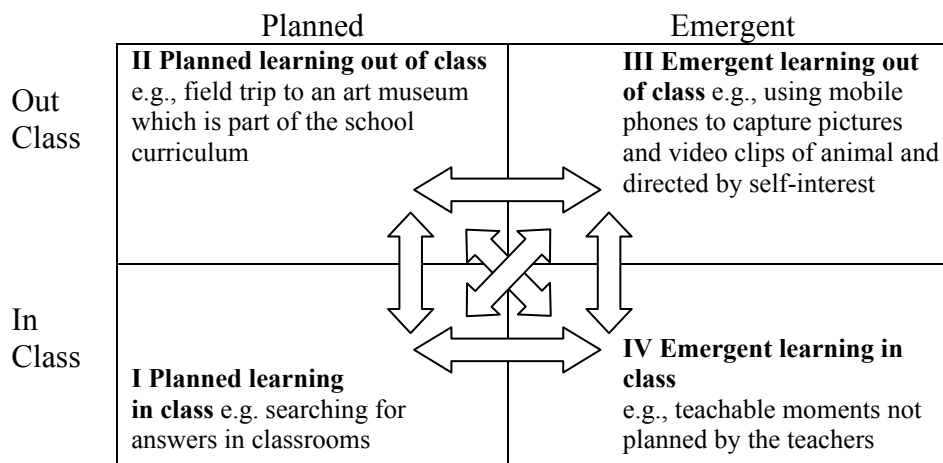


Figure 2: Matrix of students learning spaces (adapted from So, Kim, & Looi, 2008)

Our research attempts to design and investigate a seamless learning environment that allows students to learn at any time and at any location, and provides children with multiple ways of learning throughout the day. This is consistent with what Pea (2009) argues: “we need to treat the activities and life experiences of the learners throughout the day as our units of learning design, description and explanation”. The matrix above (Figure 2) shows the students’ learning spaces from two dimensions – 1) in class vs. out of class and 2) planned learning (planned by teachers) vs. emergent learning (not planned by teachers, but occurring unexpectedly driven by student self-interest/motivation).

## “Mobilized” Lesson Design

For the planned learning activities, we designed a series of “mobilized” lessons in class (Zhang, Wong, Seow, Chen, & Looi, 2009) to help students learn curriculum subjects better. Instead of relying on the textbooks for instruction, we created instructional tasks for the students to search for information related to the curriculum and scaffold their learning. The instructional tasks took advantage of the affordances of the Internet-enabled Smartphones and the GoKnow’s MLE. For example, we used iKWL to draw out students’ prior understanding and encourage inquiry about the topic. Students use the Internet-enabled Smartphones to search for resources to answer their queries. Many “mobilized lessons” have an “out-of-classroom” element where the students interact with the environment outside the classroom and engage in activities in their everyday lives. For example, we designed an English mobilized lesson on prepositions (Looi, Wong, So, Seow, et al, 2009) to support students’ multiple learning paths. In this lesson, students used the Sketchy application on their mobile devices to represent their understanding of the prepositions, and took pictures outside the classroom to demonstrate their usage in an authentic context.

## Data Collection

A design ethnography approach (Goldman, 2004) is integrated into our research to observe how students are engaged in seamless learning when they interact with their handheld devices, peers, teachers and other people in their learning community (e.g., Barron, 2006; Squire & Klopfer, 2007). Over the past 6 months, we have followed this P3 class closely to study how they use the Smartphone in and outside of the classroom. Data was obtained through extensive observations in the school. The sources of data included classroom observations, informal conversation with students during their recess breaks, conversations with the teachers, and professional development sessions with teachers as we designed and reviewed the lessons. Our researchers spent time observing and

interacting with the class every week for about 6 months. They observed how the students used the Smartphones to mediate learning in class, how the Smartphones facilitate interactions and learning with others, and the emergent use of the Smartphone.

We surveyed the students before the introduction of the Smartphone and again six months after they have used the device. In the survey, the students reported on their usage, experience and attitudes towards the use of the Smartphone for learning in and out of school. We conducted structured interviews with the students prior to their use of the devices.

In a seamless learning environment, students are ‘on the move’ across different modes of space and time. In this project, students have 24-7 access of the mobile device so that they can use the tool to engage in a wide range of activities in and out of the classroom. We have developed and installed a log software program to capture all the data stored in students’ HTC phone. To understand more about the nature of students’ learning outside school, we selected six students from a diverse set of criteria (academic performance, technology competency, socio-economic status, social skills and richness of informal learning spaces) for in-depth study. For these students, we conducted monthly visits to their home where we interviewed them and their family members. Through the visits, we hope to understand the informal learning environment of the student at home and outside school. Each family was given a digital camera to capture moments that reflect the student’s use of the Smartphones during family activities.

## Findings

In this section, we describe a myriad of seamless learning scenarios based on our preliminary findings of the data collected from the research. The scenarios describe how technology facilitates learning in and across the boundaries presented in our framework in Figure 3. We present survey results on the 39 students’ experiences with and attitudes towards the Smartphone and its role in learning 6 months after the introduction of HTC phones (September 2009) and “mobilized lesson. We also compare students’ attitudes toward using Smartphone for their learning in and out of classroom before (February 2009) and half year after the introduction of HTC phones and “mobilized lesson”.

### Seamless learning Scenarios

#### Planned Learning in the classroom – Planned learning outside class

In a lesson on digestive systems, the students learnt about how a digestive system functions as a system. They had to understand how different parts of the human digestive system worked together to digest food in the body. Planned classroom activities included viewing of videos on students’ Smartphones and creating animation on the synergistic processes of the digestive parts. The process of creating the animation enabled students to grasp why and how the seemingly disparate parts actually work in tandem as a system. For the planned home activity, the teacher wrote a letter to the parents of the students to invite them to participate in the activity. Students were required to teach their parents on what they know about the digestive system. After the parents had learnt about the digestive system from the child, they were asked to share and recount the parts and functions of the digestive system. The students then used the Smartphone to video or audio record what the parents have shared about the digestive system.

In class, the teacher paired the students and instructed them to listen or view their partner’s recording (Figure 4). As they listened or watched the presentation, each student would have to evaluate the parent’s knowledge of the digestive system by using checklist provided to them. For example, students need to validate if the parents have indeed described the flow of food in the digestive system or demonstrated understanding of where digestion stops in the system. Learning inside and outside the classroom became a participatory activity between students, teachers and parents. Students took on the role of teaching their parents what they learnt and students learnt from their friends through their feedback on the recording. We noticed that students did exhibit accountability for what their parents had shared and they critically reflected on what they had taught or omitted during the child-parent sharing. One student in the class was concerned that he had omitted “teaching” his father a function of the digestive system. This happened after his partner said that he did not hear any mention of it from the video recording of the student’s father.

#### Planned learning in class – Emergent learning out of class

In our planned lesson, we encouraged the students to inquire what they would like to know pertaining to their selected topic. For example, after students listed all that they know about animals, we asked them to list the questions they would like to know about animals. There are no restrictions on the type of questions they can pose. Using the Smartphones, they were encouraged to use the Internet to search for the answers to the questions. As young learners of inquiry, they had initial difficulties in framing the questions. They also needed support from the

teacher and researchers in helping them to make sense and filter the influx of information that emerged from their search results.

In class, we promoted inquiry by asking students to list questions they have about a topic and look for evidences that would help them answer the questions. They would use the 3G-enabled phones to search for answers and share their answers in class discussions facilitated by the teacher. The planned lesson on the inculcation of inquiry skills actually spills over to learning practices at home. In one of the interviews with Roy (one of our six targeted participants for ethnographic study) and his family, his father commented that Roy developed an interest in asking questions about things around him. His mother recounted that Roy taught her that guppies give birth to young instead of laying eggs. In one of the lessons, students used the Smartphone to inquire “which fish give birth to young live?” and “which mammal lays eggs?” In class, we encouraged the development of cognitive processing skills which includes observation, recording observation on the Smartphone with the camera, and sharing with others. At home, Roy observed that the fishes in his home aquarium had laid eggs (Figure 3). He used his Smartphone camera to take pictures of the eggs. His interest and habits of inquiry was supported by his parents. On a holiday trip, Roy recorded videos of the fishes and marine life from the transparent base of the boat he was in (Figure 4). The Smartphone is a tool to support Roy’s emergent learning arising from his interest in marine animals. He used the Smartphone to record his observations outside the class and search for more information. He has learnt to be observant about the world around him and started to find out answers to his questions independently. Roy told us that he shared his pictures and videos with classmates who shared similar interests in marine animals.



Figure 3. Roy taking pictures of eggs laid by the fish in his home aquarium



Figure 4. Roy taking pictures of marine life he observed from the transparent bottom of a boat

### Emergent learning in classroom - Planned learning out of classes - Planned learning in classroom

Jeremy was one of the participants in our study who showed a keen interest in exploring the use of the mobile devices when it was first introduced in the classroom. During class, he was observed to explore both the hardware and software features of the Smartphone (Figure 5). In one lesson, he used Google Maps to find the location of the school and his home on the map. His exploration was unrelated to what was taught in the class at the time. He was zooming and panning the map to locate, and making spatial comparison to the location-in-question with respect to his neighbourhood. He used Google Maps to find directions from the school to his home by entering the start point and end point of his journey. In a home interview, he shared with the researchers his motivation of using Google Maps - his grandmother had problems travelling from one place to another as she does not know the directions. He planned to use Google Maps to help her get around. Jeremy’s exploration extended to the social realm as he shared with his classmates about the use of Google Maps. During class, Jeremy and another classmate used Google Maps to compare the distances of their homes from school.

Some of our ideas for learning design are inspired by the students’ innovative use of mobile devices in the emergent learning spaces. For example, when the mobile devices were first introduced to the class, some students used Google Maps to find the location of their homes on the map (Figure 5) and compared the distances of their homes from school. To connect the students’ emergent use of the Google Maps on the Smartphone to in-school instruction, the teacher designed a math learning activity for the students to learn distances and length in an authentic context.: Each student was asked to find the distances and directions from one point to another point (e.g. from the school to the swimming complex) by using Google Maps. They then added up the length of the journey and converted the distance from Kilometers to meters. The use of Google Maps enabled the students to have a better sense of distance as the interface displays the directions to places they are familiar with such as the swimming complex or the nearby shopping mall from the school. It enabled them to relate distance and time by viewing the

estimated time needed to reach a destination using different modes of travel such as walking or driving using Google Map.



Figure 5. Jeremy exploring Google Map in class



Figure 6. Aaron viewing collection of fishing rods

### Emergent learning outside class - Emergent learning in class - Planned learning in class

Aaron had a strong interest in fishing. His interest was fuelled by his family activities which include weekend overseas trips for fishing trips on a boat. His house was filled with equipments and artifacts which reflected the family's interest in fishing (Figure 6). During interviews, Aaron showed his fishing equipment to the researchers. At home, he used the Smartphone to view YouTube videos of the marine life. Using search terms on YouTube, he found videos that meet his interest on demand. In the classroom, Aaron shared his videos and knowledge with classmates. One of the students with whom he shared his interest is Roy. In our interview, Roy told us about Aaron telling him how fast a swordfish could swim in the deep sea. This sparked off an interest for Roy to watch "Blue Planet" and borrow books from the public library on the deep sea creatures.

Aaron's interest in the marine life extended to his knowledge about animals. In a lesson where the teacher asked students to animate the characteristics of the mammals, Aaron drew an Elephant Shrew. He correctly identified the characteristics of a mammal. His choice of drawing an Elephant Shrew showed his knowledge of animals. He asked questions about fishes such as "Where do Red Groupers live?", "Where do Water Hares live?" and "How do fish lay eggs?" in his KWL chart (What do I know, what do I want to know, what have I learned) in the Smartphone. His knowledge about fishes is impressive for an 8 year old as he stated that "Rabbit fish live in holes in the water", "fish have gills to breathe in water", and "fish use their fins to swim." In class, he continued to increase his understanding and interest using the Smartphone to look for information and view videos.

### Students' Attitudes towards Smartphones for Learning

The scenarios described above provided us an understanding of how individual student learn in different contexts, in and out of the classroom, and across different social contexts over time. This project seeks to examine changes in the 39 students' attitudes towards learning with the Smartphone in and out of classroom after introduction of the devices and designed lessons. In the survey, the students provided feedback on the affordances of the Smartphone and its role to helping them to learn after six months of usage. The survey results are presented next.

Among the 39 students, around 80% of the students feel Smartphone helps their learning. 85% agree that the Smartphone help them learn class subjects and 79% agree that Smartphone help them learn things outside of school. 62% students agree that they understand better the science concepts learned in class and how things they learn in class are connected to their daily lives.

Table 2. Students' attitudes towards HTC phone & its role for learning (N=39)

	Agree (%)	Neutral/ Not sure (%)	Disagree (%)
It is easy to use.	71.8	20.5	7.7
It is light enough for me to carry.	74.4	17.9	7.7
The size of the screen on the HTC Smartphone is too small to do my school work.	25.6	10.3	64.1
The size of the keyboard on the HTC Smartphone is too small to do my school work.	17.9	15.4	66.7



I do <u>not</u> think that using the Smartphone helps my learning	2.6	17.9	79.5
It helps me learn my class subjects.	84.6	12.8	2.6
It helps me learn things outside of school.	78.9	18.4	2.6
It distracts me from doing my school work.	7.7	25.6	66.7
I understand the science concepts learned in class better	61.5	35.9	2.6
I understand better how things I learn in class are connected to my daily life.	61.5	33.3	5.1

When comparing students' attitudes toward the role of Smartphone in their learning in September survey with their attitudes in the February survey, we found that from the paired-sample  $t$  test, students' attitudes have a positive change towards the use of mobile devices for learning in class ( $t(38)=-2.765$ ,  $p<.01$ ) and out of class ( $t(38)=-2.321$ ,  $p<.05$ ) after the introduction of the smartphone and a series of "mobilized" lessons (Table 3). Students like the learning activities using computers and gadgets more than before ( $t(38)=-2.016$ ,  $p<.05$ ).

Table 3. Results of paired-sample  $t$  test on students attitude (N=39)

		Mean	Std. Deviation	$t$
Mobile device helps me learn my class subjects.	Feb Survey	1.46	.643	-2.765**
	Sep Survey	1.82	.451	
Mobile device helps me learn things outside of school.	Feb Survey	1.42	.683	-2.321*
	Sep Survey	1.76	.490	
I like the learning activities using computers and gadgets.	Feb Survey	1.05	.223	-2.016*
	Sep Survey	1.23	.536	
I learn more when I work in a group than alone.	Feb Survey	1.37	.633	-2.634*
	Sep Survey	1.68	.662	

\* $p<.05$ , \*\* $p<.01$ .

Both survey questions asked students if they think they can learn by "playing video and computer games", "watching videos on the computer or the web", and "browsing the Internet". Before the HTC phone introduction, only 26% students feel they can learn by "playing video and computer games", 38% of them think they can learn by "watching videos on the computer or the web", and 65% think they can learn by "browsing the Internet". Half a year later after the introduction of HTC phone, the percentage increase to 56%, 87% and 92% respectively. After 6 months of using the Smartphone, a student gave the following feedback in the survey:

I like to have more projects on My Projects and have more Sketchy activities. Sketchy helps me learn to raw (draw) nicer, write nicer, it helps me to search for more information from the Internet....The Internet helps me to search for pictures I like and searching for more information.

The use of the Smartphone facilitates the students learning and fulfills their own personal interest. Another student commented: "I like using because it has games, worksheets and teaches us more about animals, fungi, materials, length and many other more." A student indicated her interest in using the Smartphone outside of school when she said "I prefer to use the phone outdoors like in the zoo or park."

## Conclusion

This paper discusses how the affordances of mobile technology match the premises of seamless learning, and present seamless learning scenarios from our research. Till recently, not many studies in the literature make full use of the vast potential for learning spaces out of classroom to enrich school education. Studying in and out of class learning will enable us to gain insights and build theory on the notion of seamless learning. As discussed in this paper, students' learning spaces can be enhanced or extended by mobile technologies which support learning across multiple contexts and time scales. Mobile technology can support seamless learning in a variety of contexts over long periods of time. By enabling learners to learn 'anytime, anywhere', mobile technology augments the propensity for students to engage in self-directed learning on the fly. Student could adapt the use of mobile technology in different contexts for different purposes that could be related to their interests or learning goals. The mobile technology enables students to learn, through ways of organizing ideas, memories and personal resources, to support

seamless learning. It enables students to describe and preserve their observations and reflections, by means of diaries, planners, timelines, picture taking and audio/video recording etc.

From our initial findings, we observed how learning occurs and is connected seamlessly across the boundaries through social interactions and the environment mediated by the use of the technology. Students view the Smartphones as learning tools as they use it over time inside and outside the classroom. Understanding technology-supported seamless learning is important for researchers and practitioners who are interested in connecting classroom learning and out of classroom learning spaces in order to create rich and holistic learning experiences for the students. We hope this paper will stimulate further discussions on how to design and study seamless learning environments that can foster 21st century knowledge and skills among the young generation of learners.

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