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Crossing border: Mobile technologies integrating into STEM activity in and out of classroom

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Abstract: In this paper, we will present a theory contributing to the development of seamless learning and mobile learning namely: boundary activity based learning principle (BABL), which has been developed by research team for more than two years. The BABL principle has been integrated into the design of seamless learning in science and STEM education. In the paper, we will overview the basic principle of BABL, and present an integrated STEM activity at a primary school. The research will inform the STEM instructional design supported by mobile technology.

Keywords: BABL activity, STEM education, seamless learning, pedagogical design

1. Introduction

STEM education is the hot topic and has permeated into different levels from the primary schools to universities. The definition of STEM education can be broad or narrow. Most of researchers and educators agree with the definition that STEM education is an instructional approach that "integrates the teaching of science and mathematics disciplines through the infusion of the practices of scientific inquiry, technological and engineering design, mathematical analysis, and 21st century interdisciplinary themes and skills" (Moore et al., 2015). The approach fosters a closer connection among engineering and technology design and science and mathematics learning to prepare students to meet the challenges of modern society. Therefore, the nature of STEM education is mostly identified as interdisciplinary approach.

So far, the STEM education has been stated in many educational and policy documents in the world. The STEM education is very active in the primary schools. In Hong Kong, the STEM elements have been written into the primary and secondary curriculum framework (EDB, 2019). Many research has been conducted to explore the status of STEM education at schools. So et al., (2018) looked into the STEM projects at primary schools through content analysis. They found that students managed to apply multiple disciplinary core ideas and crosscutting concepts into the design and implementation of these projects. It has shown the integrative approach with the connection of science, engineering, and mathematics in science education. However, more engineering and science activities than technology and mathematics activities were adopted by the students in their projects. The problems they found that science was not significantly related with technology. And student had difficulties in refining the solution using engineering knowledge and skills. On the other hand, teacher factor was one of the major problem of STEM integration and implementation. Most teachers did not currently have the knowledge to bring integrated STEM to the classroom, and found the balance of developing skills and teaching content knowledge challenging and they overall still viewed STEM disciplines as separate entities (Dare et al., 2018). When designing and implementing integrative STEM activities, it was found that teachers had difficult in communicating with teachers of other subjects due to the nature of other disciplines (Lee & Shin, 2014). Ge et al., (2019) investigated a total of 248 with 120 primary and 128 secondary school teachers' self-efficacy and concerns about STEM education. The results showed that only 5.53% of teachers are well prepared, and almost half of the teacher are not ready for STEM education. Teachers expressed intense concerns on "information- pedagogy/resources/support", "Management- organizing, managing, and scheduling the instructional activities" and "Consequencethe impacts on learning and professional development" about implementing STEM education in schools. These all affected the integrative nature of the STEM education activities, and the effective implementation of STEM education.

For addressing the above problems, we propose the use of BABL principle as the pedagogical guide for promoting and improving the pedagogical design of STEM activities, which has been integrated into science learning supported by mobile technologies and reported (Sun & Looi, 2018). Therefore, we will briefly introduce the theoretical foundations BABL and show the case study of integrating BABL in STEM education as the exemplar of the potentials of BABL in STEM education.

2. Theoretical Foundations of BABL

The boundary activity based learning principle has been gradually developed in the context of science education. The key idea is that connecting the cognition and skills according to the learning contexts via boundary objects in the structural way (Sun & Looi, 2018). The boundary object has been defined as the common idea generated in the scientific work that needs cooperation among divergent viewpoints and the need for generalizable findings (Star & Griesemer, 1989). In the field of seamless learning, boundary objects can take various forms: for example, it can be the abstract concepts introduced in the classroom and elaborated outside the classroom; it can be a guiding question related to a key concept requiring students to do a series of activities to answer it; it can be an event or science phenomena, which require students' investigation outside and discussed in the class. Relevant studies have conducted research on this viewpoints: If seamless learning is well designed in addressing the generation of boundary objects in different forms, the external representations, idea thread syntheses, artifacts, mediating artefacts and its related conception, ideas, discussion can be the good representatives of boundary objects for connecting learning in formal and informal spaces (Wong, Chen, & Jan, 2012; Zhang, 1997).

Based on the literature review, we have refined the basic elements of BABL, for the details, please also refer to the paper (Sun & Looi, 2019). The key components of BABL principle can be summarized into: 1) The boundary object acts as the key component for designing the boundary activities. It serves as bridging learning in and out of classroom and capturing the learning process in the informal spaces. If the learning design should enable the generation of visible and/or invisible boundary objects, this will probably ensure students' cognition transition between formal and informal learning spaces smoothly. 2) Structure: the boundary activity is executed in pre-, during- and post- activity pattern to guarantee the continuum and stability of cognition or skills developed across the learning contexts. 3) Learning objective**:** The learner's explicit objective is to gain knowledge, skills and/or competences, and develop attitude.

Considering the interdisciplinary nature of STEM learning activities, it will have great potential for guiding and design STEM activities using BABL principle. The use of BABL would help the educators and teachers to implement STEM activities in the different learning contexts and facilitate the teaching of STEM activities supported by technologies.

3. Lesson design of STEM activity guided by BABL principle

In this lesson design, a student-centered STEM learning environment accommodating formal and informal learning environment is created. The key concepts and skills involved in these lesson plans are from primary science curriculum in Hong Kong and Mainland China. It is a comprehensive project based STEM activity. Table 1 shows the details of lesson design, please click the link: https://drive.google.com/file/d/1OHGxMN8F-MRoNaHZSBKwQzLbpSx5nA5Q/view?usp=sharing.
The topic is exploring the relationship of glass curtain wall and daily life. The inquiry-based learning principle is integrated into the activity design, with aims of guiding students' in and out of classroom activity and tracing their learning process. Most importantly, the BABL principle is used for transforming students' cognition smoothly from formal learning context (i.e. classroom) to informal learning context (i.e. out of school).
The characteristics of the lesson design are as follows:

1) Different mobile technologies: science data logger, nQuire-it (a learning system with mobile sensors), google maps (i.e. tablets) were integrated into the learning activities.

2) Inquiry-based learning principle was used for better guiding primary students' learning in a step by step manner.
3) The combination of learning in formal (i.e. classroom) and informal contexts (i.e. shopping mall) was supported by the use of science data, peer assessment and reflection in and out of classroom.
4) The elements of engineering design were integrated with science learning activities.
5) The STEM activity was a good representative of knowledge integration in STEM education.
6) Students have the ownership on searching online information, making the data collection plan, edit their survey questionnaire and conduct survey, and fill in their e-portfolio as their final report.

4. A pilot study

A pilot study has been conducted to answer the following research questions:
1) How to integrate BABL into STEM learning activities?
2) What are the impacts of BABL guided STEM learning on students' knowledge and skills ?

Figure 1 shows the key activities in the study. The whole inquiry process can be summarized as (1) students were working collaboratively for search online about the buildings surroundings with glass curtain wall; (2) using baidu map to find the best route of school-building; (3) testing their sensor equipment (4) conducting data collection at the building area; (5) drawing the design schema (5) building models. Students will go out of classroom to collect the real data in the activity (4).

The pilot study has been conducted in a primary school. 27 P-5 students participated in this study. The study focused on engaging students in a series of BABL guided STEM activities with aims of improving conceptual understanding and inquiry skills. The activities were conducted within two days. The data collection including students' pre and post tests on STEM knowledge and skills, on-site observation notes, learning artefacts (i.e. STEM design, responses to the tasks in e-portfolio).

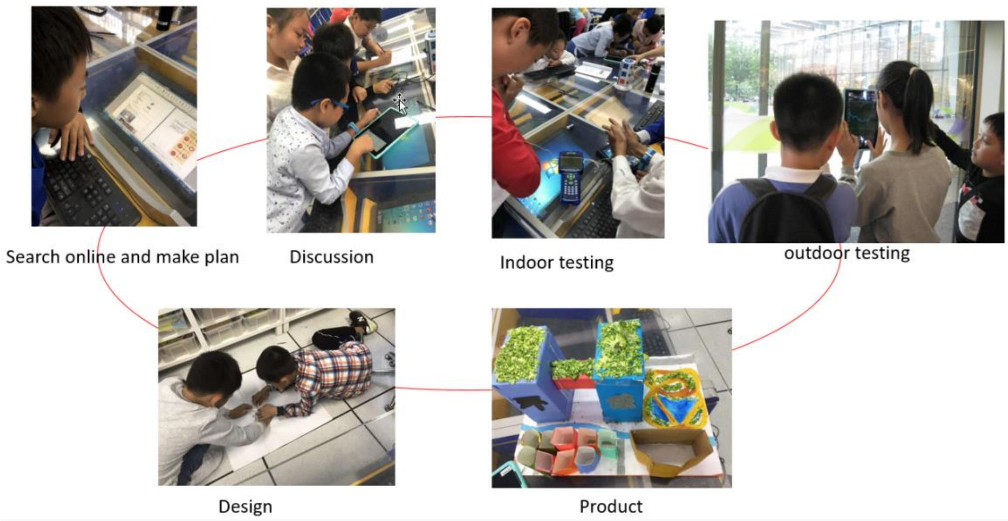

Figure 1. Key activities in BABL guided STEM activity

Figure 2 shows students final design of the life environment with low pollutions. The product shows one of group's efforts on this STEM activity. From the beginning to the end, their plan, design, exploration and model building were proposed and decided by themselves. They may not have enough background information about some activities, for example, the physical properties of curtainwall glass, the engineering design process and skills, the basic knowledge of making survey, as well as using mobile sensors to collect real data. However, their performance were out of our expectation. Most of them were working collaboratively successfully for solving the problem. Overall, the students were actively discussing with their peers on making plans, searching online information and engaged in doing outdoor activities. The high quality and creative STEM design were generated. They felt this

STEM activity providing different experience comparing with pervious learning experiences. They had more opportunities to express their own ideas and applying their knowledge into the practical activities.

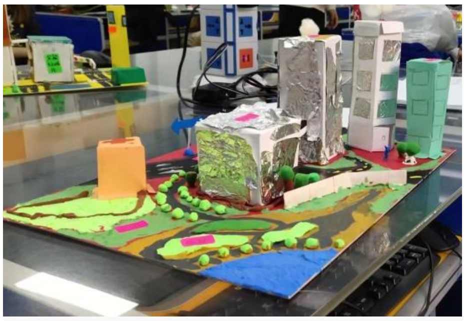

Figure 2. One of groups’ final design

5. Conclusion and Implications

Pedagogical design of STEM needs to be explored further. Our study just presents one of the patterns of pedagogical design of STEM activity. There still have more opportunities to integrated different pedagogy with STEM activities. The integration will depends on the content knowledge, skills and nature of the activities, as well as the practitioners of the activities. We need to explore this new opportunities with collecting more evidence on how students’ knowledge and skills transfer from one STEM subject into another STEM subject, how to improve the ease of transitions of knowledge and skills across interdisciplinary contexts. In the further research, we will find the boundary objects in the STEM contexts, and expose the characteristics of the cognition and skills transition in different learning contexts. The findings will used to inform the curriculum design of STEM activities and the teacher education of STEM education.

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References

Education Bureau. (2019). Curriculum Development of Science Education. https://www.edb.gov.hk/en/curriculum-development/kla/science-edu/index.html

Emily A. Dare, Elizabeth A. Ring-Whalen & Gillian H. Roehrig. (2019). Creating a continuum of STEM models: Exploring how K-12 science teachers conceptualize STEM education, *International Journal of Science Education*, 41(12), 1701-1720

Lambrg, T., & Trzynadlowski, N. (2015). How STEM academy teachers conceptualize and implement STEM education. *Journal of Research in STEM Education*, 1(1), 45-58

Lee, J.-M., & Shin, Y.-J. (2014). An analysis of elementary school teachers' difficulties in the STEAM class. *Journal of Korean Elementary Science Education*, 33(3), 588-596

Moore, T. J., Tank, K. M., Glancy, A. W. and Kersten, J. A. (2015), NGSS and the landscape of engineering in K-12 state science standards. *Journal of Research in Science Teaching*, 52 (3), 296-318. doi:10.1002/tea.21199

So, W. M. W., Zhan, Y., Chow, C. F., Leung, C. F. (2018). Analysis of STEM Activities in Primary Students' Science Projects in an Informal Learning Environment.*International Journal of Science and Mathematics Education, 16*, 1003-1023.

Star, S., & Griesemer, J. (1989). Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science*, *19*(3), 387-420. Retrieved from http://www.jstor.org/stable/285080

Sun, D.,&Looi, C.-K. (2018). Boundary interaction: Towards developing a mobile technology-enabled science curriculum to integrate learning in the informal spaces. *British Journal of Educational Technology, 49(3)*, 505-515.

Sun.D & Looi, C-K. (2019). *An Inspiration from Border Crossing: Principle of Boundary Activity for Integrating Learning in the Formal and Informal Spaces. In: Looi CK., Wong LH., Glahn C., Cai S. (eds) Seamless Learning. Lecture Notes in Educational Technology*. Singapore: Springer, Singapore.

Wong, L.-H., Chen, W., & Jan, M. (2012). How artefacts mediate small-group co-creation activities in a mobile-assisted seamless language learning environment?, *Journal of Computer Assisted Learni*ng, 28(5), 411-424.

Zhang, J. (1997) 'The nature of external representations in problem solving', *Cognitive Science*, 21(2), 179–217.

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