Queensland University of Technology
Brisbane Australia

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Adaptive Teachers Embracing New Ways of Learning with Robotics in Chinese Schools

Kar-Tin Lee & Vinesh Chandra

Queensland University of Technology, Australia

k5.lee@qut.edu.au

Introduction

> Teachers need to be led away from the 'mechanistic' approach to learning and to embrace instead the view that learning should occur in terms of an environment – combined with the rich resources provided by the digital information network. Students, teachers and the information within this learning environment coexist and shape each other in a mutually reinforcing way as well as serve as catalysts for innovation. (Thomas & Brown, 2011, p. 35)

In July 2010, China announced the "National Plan for Medium and Long-term Education Reform and Development (2010-2020)" (PRC 2010). The Plan calls for an education system that:

- promotes an integrated development which harnesses everyone's talent;
- combines learning and thinking; unifies knowledge and practice;
- allows teachers to teach according to individuals' needs; and
- reforms education quality evaluation and personnel evaluation systems focusing on performance including character, knowledge, ability and other factors.

This paper discusses the design and implementation of a Professional Learning Program (PLP) undertaken by 432 primary, middle and high school teachers in China. The aim of this initiative was to develop adaptive expertise in using technology that facilitated innovative science and technology teaching and learning as envisaged by the Chinese Ministry of Education's (2010-2020) education reforms. Key principles derived from literature about professional learning and scaffolding of learning informed the design of the PLP. The analysis of data revealed that the participants had made substantial progress towards the development of adaptive expertise. This was manifested not only by advances in the participants' repertoires of Subject Matter Knowledge and Pedagogical Content Knowledge but also in changes to their levels of confidence and identities as teachers. It was found that through time the participants had coalesced into a professional learning community that readily engaged in the sharing, peer review, reuse and adaption, and collaborative design of innovative science and technology learning and assessment activities.

Teachers engaged in workshops, which provided the opportunities for them to actively couch sound principles of learning. They gained first-hand experience in applying an aligned system of assessments, standards and quality learning experiences geared to the needs of each student. Teachers worked collaboratively in teams to create inquiry, design, and collaborative learning activities that aligned with their curriculum and dealt with real world problems, issues and challenges. They continually discussed and reflected deeply on the creative activities and shared the newly developed resources online with teachers across the entire country, an activity they were not accustomed to in the past. It is evident from the analysis of data that teachers are beginning to apply rich pedagogical practices and are becoming 'adaptive' in their approach when using LEGO® robotic tools to design, redesign, create and re-create learning activities to enhance their students' learning.

Theoretical Framework

The design of the PLP adopted the key principles as proposed by Desimone (2009). She contends that these principles are characteristics of professional development which play a critical part in increasing teacher knowledge and skills, in improving their practice, and, which hold promise for increasing student achievement. The principles included the following.

- *Content focus:* the most influential feature – the PLP focused on the General Technology and Science syllabus.
- *Active learning:* throughout the PLP, teachers had ample opportunity to engage – face to face and online.
- *Coherence:* this project was sponsored by the Ministry of Education with industry support and policy messages to teachers were consistent throughout.

- *Duration:* the PLP was conducted intensively over five days, followed by implementation in schools and follow-up workshops after twelve months.
- *Collective participation:* in the PLP teachers were grouped according to provinces and engaged in multiple forms of interaction and discourse.

In addition, four pedagogical approaches (Goldman, Eguchi, & Sklar, 2004) were adopted. Firstly, the program was underpinned by the theory of constructivism. Learners build new knowledge upon previous ones. Through this experience each learner constructs individual meanings. Secondly, the notion of Papert's (1980) constructionism -- was incorporated. The learner in a constructionist environment builds things. Thirdly, learning by design facilitated collaboration and reflection in teams. Fourthly, cooperative inquiry, which involves – contextual inquiry, participatory design and technology immersion – allowed for teacher exposure to LEGO® robotics for the first experience. The PLP placed heavy emphasis on pedagogy because the aim was to have teachers return to their classrooms with clear teaching strategies, methods, and means to assess their students' learning processes.

These four pedagogical approaches coupled with the critical principles of professional development guided the design and development of the PLP. The three phases below demonstrate the PLP cycle.

A Description of the Professional Learning Program Cycle

Phase 1 – Initial Training: The teachers participated in lecture/presentations, hands-on workshops focusing on inquiry and project-based learning using LEGO® robotics, reflection sessions, and on-line discourse. During the course of this initial training, the participants explored how design and problem solving activities based around LEGO® Education Toolsets can be utilised to facilitate innovative student-centred teaching and learning. These activities were utilised for three reasons. First, these activities can provide a nexus between theory and practice (Chandra & Chalmers, 2008). Second, well-designed LEGO® robotic activities can provide contexts where existing theoretical frameworks for problem solving in science, technology, engineering and mathematics can be applied with ease and efficiency (Rogers & Portsmore, 2004). Third, LEGO® Education Toolsets had recently been supplied to the participants' schools by the LEGO® Foundation, Semia Ltd., and the Ministry of Education.

Of significance was the fact that in Phase 1 teachers actively engaged in design challenges allowing them to demonstrate strategies and tools to solve problems. These challenges were set in a real-world context to show where and how science, technology, engineering and mathematics knowledge and concepts might be relevant. The design challenges were posed to be truly open-ended with more than one solution process and more than one solution. Challenges were peer evaluated and teachers had to reflect continually both in class and online. Through this engagement, the teachers were expected to construct their own knowledge (using LEGO® Education Toolsets across subject areas) as they investigated, designed, produced, evaluated, and reflected on their design challenges. They engaged continuously in curriculum related discussions both in class and online.

No previous familiarity with LEGO® robotics or terminology was assumed. The activities encouraged a culture of knowledge-building collaboration (Scardamalia, 2002) and teamwork. The facilitators ensured that situations were created in which all teachers' ideas and views could be heard and considered. The activities pushed teachers out of their comfort zones to facilitate their development as adaptive experts engaging in active, hands-on activities focusing on the development of problem-solving skills. The rationale here was that if teachers can move along the continuum of change and become adaptive experts, then they are 'able to approach a new situation flexibly and to learn throughout their lifetimes… they not only use what they have learned, they are metacognitive and continually question their current levels of expertise and attempt to move beyond them' (Bransford, Brown & Cocking, 2000, p. 48). When teachers acquire adaptive expertise, they also possess both the expert knowledge that is necessary for high-quality performance and the ability to be flexible and inventive in the face of non-routine situations. They possess not only conceptual understandings, but also have access to procedural competencies, models of practice, and ways of monitoring their own development (University of Minnesota, 2010).

Phase 1 was a three and a half day program. By the third day, teachers were required to design their own lessons within their teams. These lessons were then presented to the group and tried out in class. At the end of the PLP, each teacher was required to design at least three more lessons, which they would try out once they returned to their own schools. These lesson plans together with teacher self-reflections and notes for improvement were uploaded online for sharing.

Phase 2 – Implementation: During the following school year, the teachers implemented their new knowledge, skills, and habits of mind about student-centred teaching and learning in their classrooms, using the strategies derived in Phase 1. Throughout this time all teachers engaged in online discussions moderated by the project team. For the majority of the teachers, their schools were set up with a supply of LEGO® robotic kits from LEGO Foundation and laboratories provided by the Ministry of Education, PRC as part of their curriculum renewal process.

Phase 3 – Sharing/Reflection: This entailed a two-day follow-up workshop twelve months after the completion of Phase 1. Teachers reflected and shared their experiences, ideas, lesson plans and resources face-to-face and online. An electronic repository was set up to provide access to all lessons developed by the teachers.

Discussion of Findings

The analysis of data revealed that the participants had advanced their repertoires of knowledge about the design of science and technology instruction in two dimensions: *design of learning activities* ***and*** *design of assessment activities*. The analysis of data also indicated that the program had succeeded in changing teachers' awareness of what was worth assessing and how/when it could be assessed.

As we progressed through the analysis of data, we identified two other dimensions in the participants' progression towards adaptive expertise: changes in *levels of confidence* and *identities as teachers.* Initially, most participants lacked confidence about their ability to implement learning activities based around design challenges in their classrooms. However, after their participation in the PLP activities the participants felt more confident in their abilities to implement the design challenges.

Most participants had progressed beyond being (just) curriculum implementers to purposeful learning designers. Thus, rather than perceiving that they were in an awkward position of having to make a difficult choice between either coverage of content or implementation of the socio-constructivist goals of the new curriculum, most participants realised that through innovative and creative learning unit design and teaching strategies, *both* the content and the socio-constructivist goals of the new science curriculum could be addressed. Concurrent with their emerging identities as purposeful learning designers were changes to their notions about their roles as teachers. Rather than being transmitters of knowledge, they now perceived themselves as co-constructors, mediators, and inductors of their students into a scientific community of practice.

Conclusion

The findings from the study indicate that those engaged in the development of PLPs for teachers in China need to take cognizance of certain cultural factors and traditions idiosyncratic to the Chinese educational system. These findings are useful in informing the design and implementation of future PLPs for teachers in China as well as advising policy makers. Although this study occurred in China, many of the issues with respect to professional learning of teachers identified during the course of the study are not unique to China. May other countries are experiencing similar problems as they struggle to implement reforms.

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